Established by BENJAMIN SILLIMAN in 1818.

THE

AMERICAN

JOURNAL OF SCIENCE.

EDITORS

JAMES D. AND EDWARD S. DANA.

ASSOCIATE EDITORS

PROFESSORS JOSIAH P. COOKE, GEORGE L. GOODALE AND JOHN TROWBRIDGE, OF CAMBRIDGE.

PROFESSORS H. A. NEWTON AND A. E. VERRILL, OF NEW HAVEN,

PROFESSOR GEORGE F. BARKER, OF PHILADELPHIA.

THIRD SERIES.

VOL. XLIII.—[WHOLE NUMBER, CXLIII.]

No. 257.—MAY, 1892.

WITH PLATE XIII.

NEW HAVEN, CONN.: J. D. & E. S. DANA.

1892.

TUTTLE, MOREHOUSE & TAYLOR, PRINTERS, 371 STATE STREET.

Published monthly. Six dollars per year (postage prepaid). $6.40 to foreign subscribers of countries in the Postal Union. Remittances should be made either by money orders, registered letters, or bank checks.

A. E. FOOTE, M.D.,

MINERALS, SCIENTIFIC AND MEDICAL BOOKS.

4116 Elm Avenue, Philadelphia, Pa.

THE NEW RUBELLITE.

We have just received a second and larger lot of **Rubellite** from the newly opened locality in San Diego Co., California. In the latter part of March we received fifty pounds of this beautiful variety of Tourmaline and within ten days we sold all but three specimens. More than a week's hard work on the part of our collector is represented in the large consignment which has just arrived and we are informed that it embraces all the best specimens found. Two types predominate. Radial aggregates composed of columnar crystals, the radiations averaging 2 to 5 inches in diameter, often reaching 7 or 8 inches. The other form consists of single crystals thickly scattered through the matrix. In both cases the crystals are bright and well defined, often terminated and averaging one to three inches in length.

There are many variations of these types but all of them present the same exquisite shade of pink in a setting of pale lilac colored Lepidolite, making wonderfully showy specimens of a most attractive species.

For museums or the shelf of the private collector we have magnificent groups—a mass of color and brilliant crystals, varying in size from 4 × 6 inches up to 12 × 18 inches. Price, $3.50 to $15.00. The choicest cabinet specimens from 2 × 2 to 4 × 5 inches, 25c. to $3.00. Smaller specimens, 5c. to 25c.

For this new and beautiful mineral our prices are exceedingly low.

ENGLISH MINERALS.

A shipment of twenty boxes of minerals collected and purchased by Prof. Foote during the last month in Cornwall and Derbyshire has just reached us. Space will only allow us to mention a few of the many rare and interesting specimens it contains. A fine lot of the rare **Phosgenite** and **Matlockite;** several large scalenohedrons of **Calcite.** Very fine large polished brown **Barites;** a great variety of handsome polished **Fluors** and variegated **Marbles;** Satin spar, crystallized **Fluors;** a fine set of **Hydrocarbons** and many others, all of which were taken from the mines years ago.

From Cornwall: rare forms of Siderite; Chalcosiderite; Connellite; Uranochre; Stannite; crystallized **Wolframite** and **Arsenopyrite;** a great variety of Fluors; Bornite; Cassiterite; beautiful Cerussites. etc., etc. We are able to sell many of the above at lower prices than they have ever been offered.

BOLEITE.

The new oxychloride of lead, copper and silver from Lower California, occurs in blue cubes and cubo-octahedrons of great brilliancy. Perfect crystals, 75c. to $3.50.

A few small groups and fine cleavages can also be furnished. These specimens were all obtained by Prof. Foote in Paris, from the lot originally described by Prof. Mallard.

HAUERITE.

Splendid crystals of Hauerite, perfect, $1.00 and upwards; broken crystals, 25c. to $2.00.

OTHER RECENT ARRIVALS.

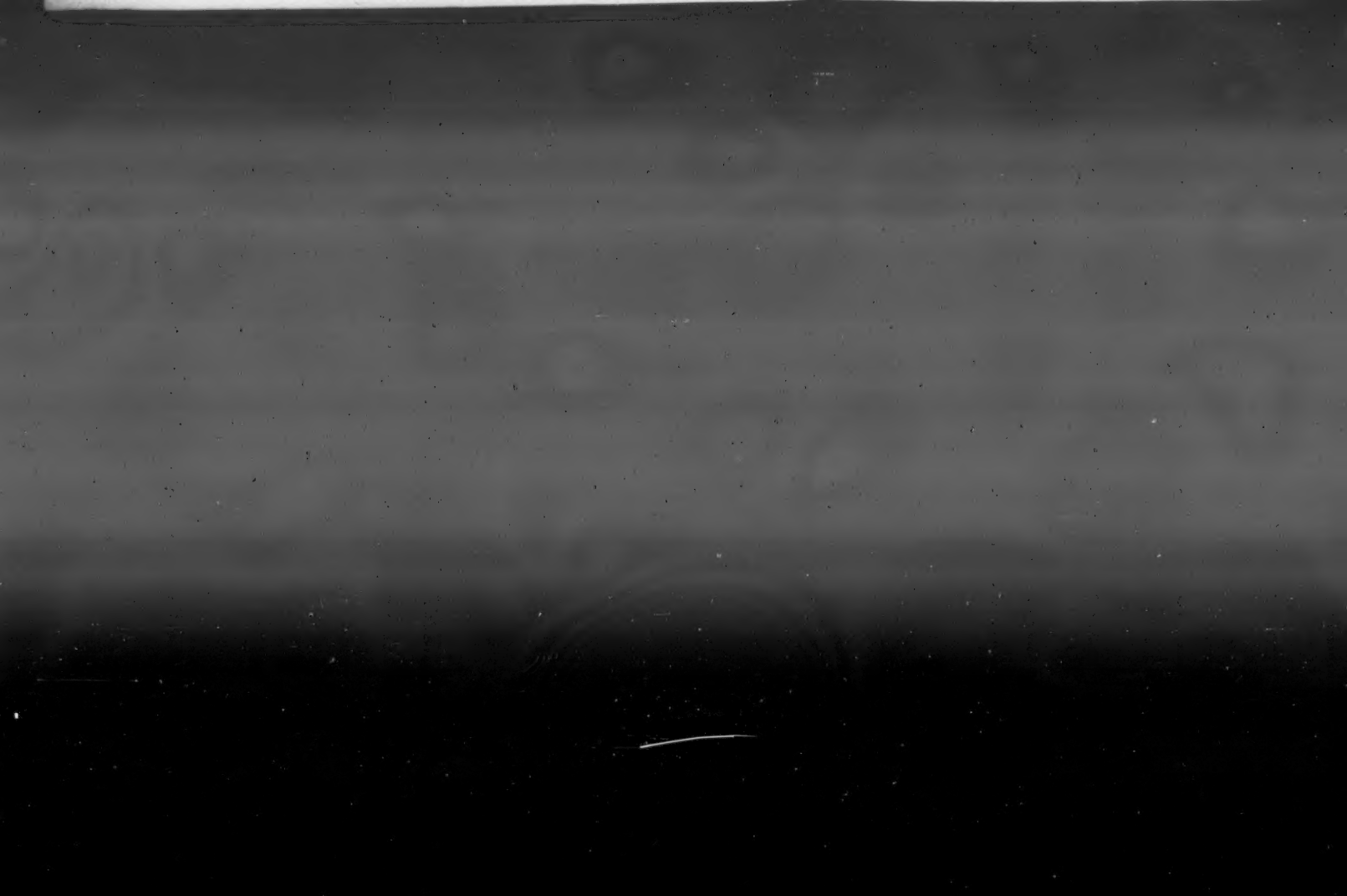
A lot of transparent doubly terminated red **Vanadinites,** 25c. to $2.00.

Rare forms of **Wulfenite,** looking like cubes, and a few which are almost perfect square prisms. From dark brownish yellow to light yellow in color, 10c. to $7.50.

A large lot of the beautiful Organ Mts. **"Flos Ferri,"** 10c. to $1.00. Larger shelf specimens $2.00 to $10.00.

Perfect crystals of **Glauberite** and **Borax,** clear and sharp, 25c. to $1.00.

Several fine groups of **Dioptase,** and many others.



THE

AMERICAN JOURNAL OF SCIENCE

[THIRD SERIES.]

ART. XLIV.—*Radiation of Atmospheric Air;* by C. C. HUTCHINS, Bowdoin College.

WE learn from the researches of Tyndall that the radiation from heated air streaming from about a copper ball heated to near redness was just detectable, but scarcely measurable with the most delicate apparatus then in existence.

He was also able to show that other gases, under like conditions radiated, some to a much greater extent than air, and he formed a table in which the different gases experimented upon stand in the order of their radiating powers. This at present comprises about the sum of our knowledge of this important matter. The recent invention of several forms of extremely delicate heat-measuring apparatus now enables us to deal successfully with quantities of heat so minute, that the ordinary thermopile gives no indication of their existence.

The apparatus used in the following investigation is something of an improvement upon that formerly here devised and described* which improvement has been effected by the substitution of a junction of the bismuth, antimony and tin alloys in place of the iron-nickel couple formerly employed.

By a peculiar method of casting these alloys into thin leaves it is possible to give them a certain amount of temper by which their tenacity is considerably increased, so that by skill and patience they can be worked into bars as small as $0{\cdot}002^{cm}$ thick, and $0{\cdot}03^{cm}$ wide. More difficulty however being experienced with the alloy of bismuth and antimony. To avoid too

* Proc. Am. Acad., vol. xxiv.

many accidents the bars in use are made a little stouter, about $0{\cdot}003^{cm}$ thick and $0{\cdot}05^{cm}$ wide, and are united to a very thin disc of copper foil $0{\cdot}1^{cm}$ to $0{\cdot}2^{cm}$ in diameter.

Such a junction has, when the component bars are each $0{\cdot}5^{cm}$ long, a resistance of four or five ohms, and consequently the galvanometer has been re-wound to about the same resistance. The result is an improvement in the sensitiveness and steadiness of the apparatus.

On account of the peculiar conditions under which we must work in determining the radiation of air we seem practically confined to Tyndall's method, using a moving mass of air, inasmuch as gases are nearly transparent to the rays from all solid bodies at ordinary temperatures. We can however improve the method in detail, making use of a moving column of air, hotter, but at the same pressure as the surrounding atmosphere, and moving at such a rate through it as to preserve definite and measurable dimensions. The following experiments deal entirely with air in the ordinary condition, neither purified nor dried. Little would probably be gained by using purified and dried air, for, as will be seen later, the radiation is mainly from the surface of contact between the hot and cold air, where more or less mixing must take place, so that the loss of heat from contact of hot and pure air, and cold and impure air, would in most respects be a less definite problem than that of the radiation from the ordinary air of homogeneous even if of somewhat variable and uncertain composition.

The variation in composition causes great and rapid alterations in atmospheric radiation, and as we cannot allow for the variations the only remedy seems to be to work rapidly when the conditions are favorable.

It has in fact been learned, at the cost of much time, that nothing can be gained by working under any but the most propitious circumstances. We must have nearly constant temperature and humidity, absence of wind, etc., if we are to expect consistency in observations made at even as short an interval as an hour. However, we have forcibly brought to mind the remarkable power that slight variations in the ordinary composition of the atmosphere have in altering its heat-radiating properties.

Apparatus.

A galvanized iron pipe three feet long, two and one-half inches in diameter is supported at an angle of about forty-five degrees and heated by one or more Bunsen lamps placed underneath. A large hole is made near the bottom of the pipe

for the entrance of air, and when the pipe is heated a strong current sets through the tube and is discharged at the top.

To cut off air currents from the outer surface of the pipe, tin screens are made to surround it and move with it. The upper opening of the pipe is furnished with a nozzle of lead, presenting an opening 1^{cm} by 3^{cm}. By burning touch paper at the bottom of the tube the lamps beneath being lighted, the shape of the column of air from the nozzle can be inspected at leisure by reason of the dense smoke that issues with it, and by filing the throat of the nozzle it can be given such a shape that the column of heated air will preserve uniform dimensions for a considerable distance from its exit. After the lamps have been lighted for twenty minutes the temperature of the air becomes constant, and changes but slightly for hours at a time.

The lower end of the tube is supported upon a pin, thrust across its diameter, so that while the bottom of the tube remains fixed, the remainder can be moved in a vertical plane by a pull upon a string, the tube falling back by its own weight when the tension upon the string is relaxed.

The thermopile points continuously to a large copper Leslie cube containing water at the temperature of the room, and furnished with a thermometer divided to 0·1°. When the observer at the galvanometer releases the pipe it falls to such a position that the hot air streams in front of the opening of the thermopile at a distance of 3^{cm} causing a deflection of the galvanometer needle after which the tube is raised by the string attached, the heated air now being discharged high above the opening leaving the apparatus unaffected save by the radiation of the cube.

The breadth of the column of air is sufficient to fill the opening of the thermopile and leave a wide margin on either side. For finding the instrumental reduction factor, a long thin copper tank is provided which may contain water a few degrees above the temperature of the room. This tank is pushed between the stationary cube and the thermopile by an assistant and withdrawn again at a signal from the observer at the galvanometer. It is furnished with a delicate thermometer which can be read to 0·01°.

Reading Galvanometer.

Both the forward and backward swings of the needle are observed, and the mean of these constitutes a single observation, the mean of five or ten observations comprising a set. The sensitiveness of the galvanometer has been frequently

changed to suit the conditions of experiment by changing the position of the controlling magnet. The period of the needle has always been kept less than ten seconds.

Reduction Factor.

The instrumental reduction factor is the amount of heat in small calories per second from a surface that fills the aperture of the thermopile, necessary to give a deflection of one division of the galvanometer scale.

The reduction factor is always obtained one or more times each day, and is considered as applying to that day's observation only. It is found by observing the deflection produced by the warm copper tank, coated with lampblack. The amount of heat radiated per degree of difference per sq. c. m. per second for the difference of temperature between the tank and cube is found from the equation $x = 0{\cdot}000238 + 3{\cdot}06 \times 10^{-6} t - 2{\cdot}6 \times 10^{-8} t^2$.* The instrumental constant $c = \frac{x}{a}$ where a is the galvanometer deflection per degree of difference in temperature between the cube and tank.

Radiation of Air.

Measures for finding the absolute radiating power of a column of air one centimeter thick at a temperature near 100° were made upon eight days. The results of each day's work were fairly satisfactory, but there was no sort of agreement between those of separate days.

A preliminary experiment upon the effect of humidity, made by measuring the radiation of the air in its ordinary state and then again after letting steam into the room from the heating pipes, showed that the radiation increases with the amount of moisture in the air, confirming the result reached by Tyndall.

The readings of the barometer, and of the wet and dry bulb thermometers were thereafter recorded. But even after making a very sensitive wet and dry bulb apparatus using two thermometers reading to 0·01° and swinging the whole from the ceiling, like a long pendulum, to the same level as the air entrance to the heated tube, I was unable to make out the exact connection between the heat radiated and the amount of moisture contained in the atmosphere. The utmost care was used and every precaution suggested by experience observed, but after more than a month no result beyond what was given in the preliminary experiments was reached. Notwithstand-

* Proc. Roy. Soc., 1872, p. 93.

ing the failure to establish a connection between the absolute amount of moisture and the radiation, the tabulated results show a striking connection between the relative humidity and the radiation, as is exhibited in the following table.

TABLE I.

a	*b*	*m*	*n*	*t-t'*	*f'*	*h*
Oct. 20	76·16	14·7	15·6	88·2	90·	0·000002562
Nov. 7	76·41	16·1	23·9	89·0	40·	1189
Nov. 9	76·76	16.7	22·8	88·7	50·	1273
Nov. 10	76·76	10·0	13·9	84·0	57·5	1559
Nov. 11	76·19	14·4	17·3	84·5	71·	1812
Nov. 11	75·80	18·9	20·4	87·7	85·5	1986
Nov. 12	75·99	14·0	17·9	88·3	62·5	1597
Nov. 13	76·38	13·6	19·4	82·6	47·	1513

a is the date.
b " barometer reading.
m " wet bulb.
n " dry bulb.
t-t' " difference of temp. between hot air and cube.
f' " relative humidity.
h " absolute radiation.

It will be seen that *h* increases quite regularly with *f*, though the plotted observations do not lie well enough upon any smooth curve to enable us to assert the law of connection, which law it would be difficult to deduce without the means of controlling the presence of other accidental constituents of the atmosphere; such as carbonic acid and gases resulting from the decomposition of dust, coming in contact with the heated tube. That these accidental impurities have a very great influence, is shown by the following experiment. On Dec. 7, the mean deflection produced by the air column at 120° was 64 scale divisions. A small amount of pure dry carbonic acid gas was allowed to mix, a bubble at a time with the air at the entrance of the heated tube. The deflection rose to 140 or more than doubled. When a very small amount of illuminating gas was mixed with the air, the deflection was too great to be recorded on the scale. As it is impossible at present to allow for the presence of these impurities or even for the aqueous vapor in assigning a value to the absolute radiating power of atmospheric air we are obliged to employ an average result obtained from several days' observations.

The following table presents the measures made on six days after considerable practice had been had with the apparatus.

The observations were made at four or more different temperatures of the air column, with a view to learning the law connecting the heat radiated and the temperature.

TABLE II.

a	*b*	*f*	*c*	$t-t'$	*g*	*h*
Nov. 23	---	---	$\bar{4}$·741067	53·7	18·42	0·0000001889
				77·6	29·9	2123
				89·3	36·4	2246
				119.0	59.7	2763
				167·5	93.8	3085
Nov. 26	76·3	7·89	$\bar{4}$·714927	53·0	14·2	0·0000001390
				80·0	27·0	1751
				86·0	29·2	1761
				96·5	35·5	1908
				138·0	64·0	2453
				167.0	92·5	1908
Dec. 4	76·0	6·50	$\bar{5}$·014392	53·0	10·37	0·0000002022
				67·5	14·9	2282
				100·0	24·3	2511
				145·0	39·9	2845
				188·0	62·5	3437
Dec. 6	75·5	4·76	$\bar{4}$·440807	64.3	32·8	0·0000001407
				83·5	40·4	1305
			$\bar{5}$·166587	84·0	9·0	1572
			$\bar{4}$·440807	115·0	57·5	1380
				152·0	87·0	1574
			$\bar{5}$·166587	185·0	21·6	1713
Dec. 7	75·3	6·16	$\bar{4}$·339524	47·0	28.3	0·0000001393
				87·5	58·6	1464
				113·0	74·2	1435
				153·5	103·5	1473
				205·0	147·6	1573
Dec. 8	76·6	5·08	$\bar{4}$·393008	46·0	20·5	0·0000001102
				82·0	43·0	1299
				104·0	51·9	1234
				160·0	106·5	1637

a is the date.
b " barometer reading.
f " absolute humidity.
c " log reduction factor.
$t-t'$ " difference in temperature between air and cube.
g " mean galvanometer deflection.
h " absolute radiation of air.—The amount of heat lost each second from each square centimeter of surface for each degree of difference between the temperature of the air and of the surroundings, the sheet of air being one centimeter thick.

Upon plotting each day's observations separately using the value $t-t'$ as ordinates, and the corresponding values of h as abscissas we find that in every case the observations are represented by a straight line. Whence we deduce that in the case of air within the limits of temperature here employed the increase of radiation is proportional to the increase of temperature. This relation will doubtless be found true of other gases, and to apply to a wider range of temperatures. The mean equation of the six sets of observations given in the table is,

$$h = 0{\cdot}000001133 + 0{\cdot}00000000711(t-t')$$

which may be taken as fairly representing the radiation of air in an ordinary room under average conditions, the sheet of air being 1^{cm} thick.

Effect of thickness of radiating column.

It was noted at the outset that the galvanometer deflection was not proportional to the thickness of the heated column of air.

A flat sheet iron pipe was made 100^{cm} long, 10^{cm} wide and $2{\cdot}5^{cm}$ thick. This pipe was substituted for the one previously used. The air exit was from a pair of jaws, one fixed, one movable, so that the thickness of the air column at its escape could be regulated at pleasure. Measures with this apparatus were made on eight days. The results were recorded as the amount of galvanometer deflection per degree of $t-t'$.

With openings less than 1^{cm}, no difference in the amount of radiation can be detected. With larger openings a small increase is observed. The results of six determinations distributed over four days are here given.

Opening,	$0{\cdot}5^{cm}$	1^{cm}	$2{\cdot}^{cm}$	$3{\cdot}^{cm}$
Deflection per degree,	0·193	0·195	0·245	0·259

We observe that radiation is very largely from the surface of contact between the hot and cold air, which seems to indicate that a heated gas absorbs all or nearly all those rays that it itself emits and that radiation takes place only when there is a fall of temperature within the limits of molecular action.

Wave length of rays.

It would probably be hopeless to undertake a prismatic analysis of the rays from heated air. We can however get a suggestion as to the length of these waves from their behavior towards an absorbing medium. A very pure plate of quartz $0{\cdot}5^{cm}$ thick was placed over the opening to the thermopile. With the air at 100° no deflection could be obtained, and even when the temperature was raised to 200° it was decided after many trials, that there was no measurable effect. Without the quartz plate the deflection was 151. The quartz plate allows 93 per cent of the sun's rays to pass it, 31 per cent of rays from red hot platinum and 3·0 per cent of rays from lamp-black surface at 100·, being in a manner progressively opaque to waves of increasing length. The waves from heated air must therefore be of great length since they seem incapable of penetrating the quartz in any considerable degree.

ART. XLV.—*Atmospheric radiation of Heat and its Importance in Meteorology;* by CLEVELAND ABBE.

(1.) IT is evident that our planet, considered as a whole and on the average of many years, loses all the heat that it receives from the sun; but all the details of this process have not yet been completely worked out. Fourier, Poisson and their disciples have treated of this radiation in the most general manner; Melloni, Tyndall, Langley and their followers have gone into some of the details as to character and quantity. These physicists have served to awaken meteorologists to the necessity of carefully distinguishing the influence of the absorption and radiation by the soil, the vegetation, the snow and the ocean respectively; even as to the atmosphere itself we have to distinguish the absorbing and radiating powers of the dry air, of the clouds or haze and of the dust respectively.

(2.) Heat is thrown into the atmosphere not only by conduction and convection from the immediate surface of continents or oceans, but the radiant heat from these surfaces is in part directly absorbed (just as is solar radiation) by the atmosphere and in part transmitted to outer space. All of the immense quantity of heat thus communicated to the whole atmosphere (viz. 50 per cent of the direct solar radiation, plus about 50 per cent of the specular reflection from the earth and water, plus all of the convection from the surface of the earth and ocean, plus a large per cent of the radiation from the earth's surface) must be lost through a process of radiation from the atmosphere as distinguished from radiation through the atmosphere; judging from the known values of these items one would *a priori* conclude that this radiating power of the whole atmosphere must average about 0·5 calories per minute per square centimeter of its outer surface.

(3.) At first thought one would say that, according to Kirchhoff's law any radiation from a mass of air must be of such a quality as to be immediately absorbed by the adjacent air in the attempt to pass through it and therefore cannot escape into space except when radiated by the very outermost layer of the atmosphere. But in reply to this we note that the processes of radiation from and absorption by layers of air within the atmosphere depend (like those of conduction) upon differences of temperature and possibly on differences in density consequently it is quite possible that heat radiated from the warmer and denser, moister and dustier layers below may in part escape directly through the upper layers into ethereal space; that portion of this heat which is absorbed by the upper layers will in turn, by a similar process, escape from them.

(4.) The fact that some such process is going on in the atmosphere has, I presume, been recognized by many although the published expressions in regard to it are generally very indefinite. It is almost invariably the case that the cooling of the air at night is attributed to the radiation of heat from the earth and the fact that the surface of the soil becomes cold is quoted as an evidence of this action. But it can easily be shown numerically that the nocturnal conduction of heat between the surface of the earth and the air above it can only affect a very thin layer of air during the twelve hours of nighttime (3 meters according to Maurer) and that there must be an appreciable radiation from the air itself.

(5.) On this whole subject the writings of Dr. Julius Maurer offer us some valuable formulæ and data; especially has he been the first (see Schweiz, Met. Beob., 1885, vol. xxii, Append. v, Zürich, 1887,) to give us an approximate value of the coefficient of radiation of a cubic centimeter of air. This coefficient he deduces from the ordinary meteorological observations of the temperature of the air at nighttime as given by the ordinary screened thermometers. Maurer finds that the cooling of the free air during night in the lower layers of the atmosphere and on the average of the whole year, namely without distinguishing between cloudy and clear weather, or calms and winds, proceeds as though a cubic centimeter of air gives up to an enclosure, 1° C. cooler than itself, 0·0000007 gram-calories per minute. Now the specific heat of air under constant pressure is 0·2377 and the density of the air to which Maurer's coefficient pertains is about 0·00129 or $\frac{1}{773}$ of water. We may therefore convert his coefficient of radiation in absolute calories into a coefficient of cooling in Centigrade degrees whence it results that the cubic centimeter of air within such an enclosure cools by radiation at the rate of $0{\cdot}0000007 \times 773 \div 0{\cdot}2377 = 0{\cdot}0023$ degrees C. per minute or 0·138 C. per hour.

Maurer finds indications that this coefficient is larger in summer and smaller in winter. The above average value results from observations of temperature for many years at St. Petersburg, Prague, Berne, Toronto and Barnaul and may be considered as belonging to air that has an average pressure of 750^{mm}, a temperature of 5° C., is nearly saturated with moisture, and contains the average amount of dust and aqueous particles that belong to the air of those stations. Maurer especially notes that the coefficient thus found is larger than belongs to pure, dry air on account of the solid and liquid particles contained in the ordinary atmosphere and participating in the radiation. He further states that similar computations based on observations made at the high stations, St.

Bernard and Säntis, give a coefficient about 15 per cent smaller.

(6.) It is evident from Tyndall's observations and those of Ångström and others that this coefficient must vary with the chemical nature of the gases contained in ordinary air and, although it is therefore of a very indefinite nature, yet we need to know its probable limiting values in order to understand the extent of the influence of atmospheric radiation upon meteorological phenomena. On this account I have applied Maurer's formulæ to other meteorological observations and during the past three years have mentioned to several physicists the desirability of the direct determination of this coefficient by ordinary laboratory methods. I am therefore much pleased that Prof. Hutchins has been able to make a direct experimental response. The values deduced by him are considerably larger than those given by Maurer, as was to be expected, because Maurer's computation considers only the average radiation during cloudy as well as during clear nights and also because it assumes that the convection during windy nights has not obscured the simple effect of radiation. Furthermore there is a possibility that the heated metallic tube of Prof. Hutchins may have given off an extra quantity of dust or of gaseous compounds all of which would increase the apparent radiation. But although neither of these determinations represents pure, clean, dry air and although both must at present be considered only as first steps in our knowledge, yet they give us invaluable indications of the possible dimensions of an important fundamental constant in meteorology.

(7.) The importance of this subject in the study of the mechanics of the atmosphere may be enforced by the following consideration of the progress of our knowledge.

(*a.*) Espy, having reasoned his way up to the conclusion that rising air cools by virtue of the work done by it in its expansion against the surrounding pressure, also clearly stated that descending air is warmed by compression (i. e. by the work done upon it) whence it is able to dissipate any fog or cloud that it contains and becomes perfectly clear; inversely, cloudless skies, whether in small patches or large regions, demonstrate in general the prevalence of descending air. The further development of Espy's principle gave rise to what is called his latent heat or condensation theory of storms, the items of which are briefly as follows; ascent is due to buoyancy; cooling is due to the work of expansion incident to the ascent; when cooling has brought the air to the dew point and to precipitation then latent heat is liberated and the cooling is checked but the relative buoyancy of the ascending air is increased, the indraft and updraft increase and the storm

grows; when the inflow is prevented, or when it brings dry air instead of moist air, then the condensation of moisture stops and the storm subsides.

(*b.*) Ferrel worked out, from the point of view of hydromechanics, the theory of the circulation of air in cyclones and in the surrounding peri cyclonic region; he also developed the mechanics of cyclones with cold centers; he then showed how ordinary areas of high pressure and cold air (which Galton in 1863 first called anti-cyclones) may result from the interaction of two or more pericyclones; he mentions without further development the radiation of heat from the air but gives greater weight to the conduction to the ground and thus explains the inversion of temperature in the clear still air of winter. Much of this was done before the publication of the weather maps of the Signal Service or indeed of any European weather bureau. Ferrel subsequently developed the thermodynamics of the condensation theory of Espy and showed its excellent agreement with all the known facts of local storms, hence it was assumed to also apply to the large storms or areas of low pressure.

(*c.*) Hann, having shown that the föhn wind is a rapidly descending mass of air whose warmth is due to an initial rain or snowfall with the evolution of latent heat and to the subsequent rapid compression of the air, follows this up by the study of the slowly descending movements as exemplified in the European area of high pressure of 1889, Nov. 11–23. He finds, as Ferrel had done before him, that in the high areas the temperature at a few thousand feet altitude is higher than that at the surface of the ground; he concludes that the average temperature for a depth of 3000 meters is somewhat higher in an anti-cyclone than in a cyclone. Hence Hann throws doubt upon the idea that an area of high pressure with cold air near the surface of the ground only, is really a mass of descending cold air; like most others he also explains that the coldness of the lowest stratum of air under a clear sky is due to radiation from the surface of the ground. Hann's array of data requires that we now consider more closely the mechanical theories of atmospheric motion; these have usually assumed an incompressible atmosphere of about 8000 meters in depth.

(8.) Some features of recent researches in the mechanics of the atmosphere may be presented as follows: A comprehensive study of fluid motions shows that air and water alike may be forced to ascend without being warmer and lighter or to descend without being colder and denser than the surrounding fluid. The currents and whirls behind any obstacle in streams of air or water are almost wholly independent of differences

of density and are caused by differences of pressure as modified by simple kinetic laws. The uprush of water at one place and its downrush, as a whirlpool, at another place in a swift stream is a vortex phenomenon in which temperature and density have no part. The rise of the surface of a river at any bend in the channel or at the junction with a tributary stream is a kinetic phenomenon; so also is the resulting surface overflow to the right and left of the channel; so also the slow spiral circulation that goes on, in consequence of which the surface water flows from the center out to the banks of the river then down to the bottom of the channel and thence up to the swift surface and back to the banks again.

We must expect to find similar phenomena in the atmosphere where, corresponding to the general current of a river, we have a general circulation of air due to the greater warmth of equatorial air and to the swift diurnal rotation of the whole atmosphere about the polar axis.

(*a.*) Ferrel was the first to show that the tropical belts of high pressure are due—not to local cool air or to local density—but to the interaction of pressures and that they would exist if the atmosphere were a mass of incompressible fluid; they may be affected to some degree by various forms of resistance, they may also be affected by temperatures due to local radiation and convection, and also by thermodynamic relations, but all these are minor incidents subordinate to the action of the hydro-dynamic laws that bring them into existence.

(*b.*) Ferrel maintains that areas of high pressure with cold anti-cyclonic winds give evidence of originating with upper currents of air such as those that are conceived to flow out from great cyclonic areas and be whirled toward each other; Ferrel's reasoning would justify his conclusion that there is only sufficient energy in those whirls that are due to the general circulation between the equator and the pole, to generate very moderate high and low pressures but not the great barometric depressions and elevations that characterize the low and high areas. He therefore looks to the latent heat of the precipitated vapor as not only maintaining the lows but furnishing the energy that enables these to overflow as pericyclones which by interference among themselves give rise to the high areas.

(*c.*) It has been shown by Prof. Finger of Vienna that westerly winds have a tendency to rise above the earth's surface due to their excess of centrifugal force, while easterly winds having a deficiency tend to press down upon the earth's surface; but these effects are inappreciable in our barometric measurements and cannot be quoted as efficient mechanical causes for the production of high or low pressure.

(*d.*) Besides the horizontal movements and whirls, Helmholtz has studied what may be called the vertical whirls or the general vortex motion of which the ideal case is an atmospheric vortex ring surrounding the earth at the equator and moving, as a whole, poleward. If such a ring of incompressible air is to retain its energy as it moves northward and is to contract as the circles of latitude diminish, it must exhibit far greater velocities than are observed, therefore some way must exist by which it loses its energy. If, however, by reason of the irregularities of the earth's surface such rings become broken up each part will revolve as an independent ring having an inclination to the earth's surface and by the interferences and mixtures of these rings the motions may become reduced so as to agree with the observed winds. From this point of view all movements from the equator carry rapidly revolving air into regions where the rotation is less rapid and such air must rise above the earth's surface, whereas for motions toward the equator the air must descend and hug the earth's surface thereby acquiring the greater speed of rotation that belongs to low latitudes and forming local high pressure areas.

(*e.*) We see therefore that whether we study horizontal or inclined or even vertical whirls in the atmosphere, we are alike brought into the presence of ascending and descending motions which the air is forced to take for purely kinetic reasons. So long as we, with the above-mentioned authors, consider only the ideal case of a homogeneous, incompressible, dry atmosphere having an average depth of about 8000 meters and whose temperature at any point depends upon its absorption of solar radiation and upon its warming up by conduction, we have perhaps no need of a special study of the thermodynamics that is so important in the real atmosphere of compressible air. For such a problem it may therefore be sufficient to assume, as seems to be implied by Ferrel, Hann and Helmholtz, that the air loses heat by the simpler process of conduction to the cold earth. But when we investigate the real atmosphere on the basis of actual observation we find that the thermodynamics of the compressible air adds a most important feature.

(*f.*) We have thus far concluded only that local areas having a slight excess or deficiency of pressure would be maintained if the atmosphere were perfectly dry and were an incompressible fluid; but if the air is moist and is compressible then the regions of diminished pressure give rise, by Espy's thermodynamic process, to the formation of clouds and rain which form temporary and local episodes in the general motion. Such condensation of moisture especially tends to form in the rising part of the circulating air, and thus coöperates with the general mechanism to produce spiral, ascending currents that intensify

and prolong the meiobars and therefore the overlapping pericyclones of Ferrel or vortices of Helmholtz, thus eventually intensifying the pleiobars.

(*g.*) According to these views the primary factors in the origin and maintenance of local rains, water-spouts, thunderstorms and tornadoes are local buoyancy, expansion, thermodynamic cooling, condensation and latent heat. On the other hand in extensive storms of the temperate and arctic zones it is the slight depression, due to a whirl in the general circulation, that determines where a storm or low area will originate. Finally in tropical hurricanes the general circulation must decide whether an initial local disturbance shall die away or shall be fed and developed into an extensive hurricane.

(*h*) So mobile is the air that two conflicting currents cannot produce any considerable excess or deficiency of pressure and such a mechanical heaping up, or compression, as would produce a barometric gradient of $0{\cdot}1^{mm}$ per degree is immediately followed by a movement in the air that will relieve the excess. Therefore, as Ferrel distinctly shows, we must not expect that any obstruction to the moderate currents of the general circulation can explain such great barometric elevations as occur in the high areas of the United States or Europe. A slight mechanical excess of pressure may possibly initiate a high just as a deficiency does a low, but the further development of the pressures must depend upon other considerations. Among these latter Ferrel so long ago as 1856 showed that just as the low pressure depends upon the centrifugal forces due to a cyclonic whirl so the high pressure depends, at least in part, upon a centripetal force due to an anti-cyclonic whirl.

Again Ferrel has stated that if the cold of the lowest layer in the high area extends upward then the weight of this dense air would help to explain the high pressure. This suggestion needs careful consideration in view of the observed presence of warm air in the upper layer where cold air was supposed to exist. Although Ferrel maintained that the air in the high areas must on the average be colder and therefore be descending by virtue of its own gravity yet he has not made clear the details of the process by which descending air can become cooler and denser.

(*i.*) The existence of warm air above the cold layer near the ground has long been recognized for moderate elevations during clear nights; its influence upon the atmospheric refraction is apparently often very notable in astronomical observations. The fact of its existence has also been brought out, even for the daytime, by many balloon observations notably those of Glaisher in England and of Mr. Hammon in the United States (see the Am. Met. Jour., Feb., 1891.) To the

early observations of the Signal Service at Cheyenne and subsequently at Pike's Peak, as displayed on the daily weather maps, we owe the knowledge, that has these twenty years been public property in the United States, that warm air exists above the western side of our great cold waves. Ferrel in his "Recent Advances" explains this upper warm layer as due to the compression of the descending air which latter eventually flows horizontally above the lowest layer which latter is composed of air that has cooled by conduction to the cold ground near which it lies quietly resting; he states furthermore that an additional cooling is due to the evaporation of moisture from the soil and also to the "radiation of the air" but no special importance is attached to the latter factor nor to the fact that often during daylight sufficient solar heat does not penetrate into the lowest stratum to dissipate the haze and fog that is often formed during the nighttime. Hann has presented the details of the continued existence of such a warm layer for many days over the midst of the European area of high pressure of Nov., 1889; his suggested explanations, so far as they go, agree with Ferrel's.

(*j*.) But the slow horizontal flow, the evaporation of moisture from the ground and the conduction of heat to the ground by the air within a few meters distance, explain only a portion of the observed phenomena. We need a thermal process that shall do for the high area that which the condensation of vapor, and its precipitation as rain or snow, do for the low area. I have been accustomed to explain this abstraction of heat in a general way as due to the warming of the air by compression and the loss of this evolved specific heat by direct radiation, but the numerical application of this idea was hindered at first by our ignorance of the coefficient of radiation and eventually by the very small coefficient deduced by Maurer. The larger coefficient of Hutchins and a conviction that Maurer's value is too small, lead me with some confidence to ask the attention of meteorologists to the present study from which we find that we need not hesitate to accept Espy's conclusion that a cloudless blue sky demonstrates that descending movements are present and are more efficacious than any minor ascending movements that may be present. The existence and qualitative influence of radiation from the air was discussed by me with Ferrel before the publication of his "Recent Advances" and admitted by him as a possibility, but in the absence of any knowledge as to the coefficient of radiation Ferrel seems to have decided to mention the subject only in a general way.

(9.) If the air itself radiates its own heat then the temperature of an ascending or descending mass, or the general law of the diminution of temperature with altitude must depend upon

the time during which radiation has been progressing and this duration will enter as an exponent in the analytic formula. Again the enclosure to which this heat is radiated, as imagined in connection with Maurer's coefficient, is on the average 1° C. cooler than the radiating mass, therefore its dimensions may be calculated and it appears that, near the earth's surface, the lower portion of such a sphere is cut off and is replaced by the cold ground which is equivalent to diminishing the size of the sphere or increasing the rate of radiation; a similar consideration obtains at the outer limit of the atmosphere; in general the radiation of a descending mass causes it to cool least rapidly when at a medium altitude above the ground or in the midst of the atmosphere.

As for conduction between the earth and the air it is easily recognized, as Maurer has shown, that this has an inappreciable influence during twelve hours at three meters above the soil or during 48 hours at six meters; it can only become moderately important for calm air during long arctic nights. As concerns convection of heat by currents rising from the earth this will directly affect the dry, cold, clear, calm air in the midst of high pressures only up to a moderate altitude, say 1000 meters, and that only in the warmer part of the day because the rising currents are rapidly cooled by mixture and cease rising at an altitude whose limit in such weather is usually defined by a thin layer of dust and haze. Up to this altitude therefore atmospheric radiation of heat, during 24 hours of day and night, may be partially compensated by convection during sunshine but this limit is much lower for still air lying over ice, snow or water. As concerns the cooling due to evaporation this can be computed from the known amount of evaporation and is a very small quantity for the cold air over the land north of latitude 50° where our high areas form.

Therefore the factors that principally affect temperature in extensive areas of high pressure are: 1. The direct absorption by the air of the solar radiation. 2. The direct radiation by the air of its own heat. 3. The thermal changes due to changes of barometric pressure in the radiating mass which are themselves due principally to its descent in the atmosphere.

(10.) With regard to the direct absorption of solar radiation, the bolometric researches of Langley show that the general coefficient of transmission of solar radiation through the atmosphere varies from about 0·8 in the red and 0·6 in the yellow to 0·4 in the violet and averages approximately 0·6 for the whole spectrum. These figures relate to the general absorption of a zenithal ray passing through the whole atmosphere down to the layer whose elastic pressure is 760^{mm} and give no idea of the special absorption of specific wave-lengths that may

radiate from the sun or the earth. The corresponding transmissions for the same rays, when they have penetrated only down to the layer at 10,000 meters altitude or down to a pressure of 217·4^{mm}, are 0·939 in the red, 0·864 in the yellow and 0·769 in the violet; hence 0·14 and 0·26 and 0·37 are the respective fractions of the original heat absorbed from the ray in its passage through the lowest 10,000 meters of the atmosphere. Now the relative thermal intensities of these radiations are respectively 68, 108 and 52 and for the present approximation we may consider that about 20 per cent of the original incident solar heat (3 gram-calories per sq. centimeter per minute) is distributed by absorption along the 10,000 meters of this lower path. Therefore during the slow descent of air in the midst of a high area the principal external source of heat is the direct absorption of solar heat and this, at its maximum for zenithal rays, can in the lower atmosphere only amount to an absorption of $0{\cdot}20\times3\div10{,}000\times100=0{\cdot}000{,}0006$ calories per minute per cubic centimeter of air; in northern latitudes and on the average of the ordinary 6 to 12 hours of sunshine the absorption becomes much less; for Central Europe in November the average for the whole duration of sunshine would be less than 0·000,0002 calories per minute.

(11.) As opposed to this gain of heat we have only the loss by direct radiation which is, according to Maurer, expressed by 0·000,0007 gram-calories per minute per cubic centimeter or 0·0006 calories per kilogram mass of air when the surrounding enclosure has an average temperature 1° C. less than that of the radiating mass.

Without discussing the nature of the diffusion of heat by radiation or conduction within a gas, we remark that Maurer's coefficient of radiation relates strictly speaking to a mass not to a volume; we may plausibly assume that the unit mass of air has the same coefficient whatever the density of the air, at least within a pretty wide range, therefore it will follow that the rate of linear descent within our atmosphere that produces a rate of compression and dynamic warming sufficient to compensate for the cooling by radiation must be greater at high altitudes than at low ones.

Dusty, hazy or moist air, as also the ammonia and the hydrocarbons or the carbonic acid ordinarily present in the air, have somewhat larger specific heats than those for clear dry air, but they also all have larger coefficients of radiation so that their cooling by radiation is more rapid than that of pure, dry air.*

* A parallel process must take place in the solar atmosphere if we suppose the gases that ascend from the immediate surface of the sun to be at such a high temperature that all the chemical combinations ordinarily known to us are dissociated; when a mixture of such elementary gases in this highly heated condition ascends until by expansion it is cooled to the temperature at which chemical com-

This atmospheric radiation, moreover, continues day and night and is much more effective in direct cooling than the solar radiation is in direct warming. Since the loss by radiation may according to Prof. Hutchins, be far greater even than this and since Maurer's figures represent only an average for all kinds of weather we are fully entitled to at least the general statement that the cooling by radiation is to only a very slight extent offset by the direct absorption of solar heat and that its coefficient may vary from the minimum value of 0·1° C. per hour, as previously computed, up to an unknown and much higher limit.

The actual rate of cooling varies approximately as the difference of temperature of the radiating mass and its enclosure and this is probably least in the mid-atmosphere as before stated and must increase as the mass sinks to the region where the colder terrestrial surface becomes an integral part of its enclosure and especially when the effect of conduction to that surface is superadded.

(12.) The thermodynamic warming by compression takes place at the rate of about 1° C. for each 100 meters of descent. As the coefficients of absorption and radiation are uniform for equal masses or for equal changes in barometric pressure as we descend in the atmosphere, the thermal effects therefore vary more rapidly for a given change of altitude at low levels than at high levels; therefore in the early stages of any descending motion the downward movement may be accelerated but there will be a tendency towards a steady rate of descent such that the loss of temperature by radiation exactly counterbalances the gain by compression. If we accept Maurer's coefficient and diminish this by a unit in the seventh decimal place in order to allow for the absorption of solar heat, as just calculated above, we have a resultant 0 000,0006 gram-calories as the loss of heat on the average of twenty-four hours; this corresponds to a diminution of temperature of 2·88° C. per day and if this is to be compensated by compression it will require a descent at the rate of 288 meters per day; a more rapid cooling by radiation, such as is required by Hutchins' coefficient, would require a proportionately rapid rate of descent. Such a thermodynamic compensation would bring

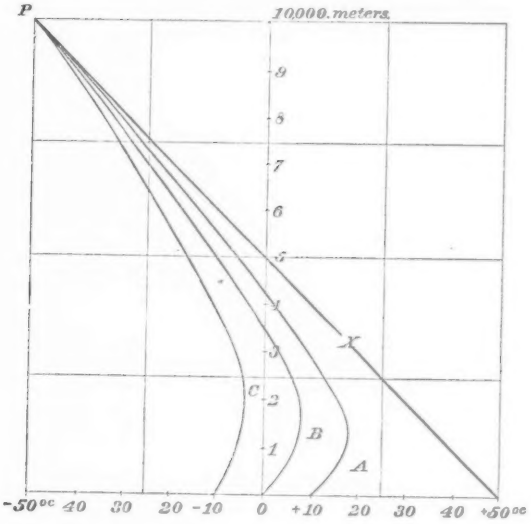
binations are possible then these take place and generally with an evolution of heat (the latent heat of combination). The continued evolution of this heat compensates for further cooling by expansion just as the latent heat of vapor operates in Espy's theory of storms; when however the combined gases have further cooled by expansion and radiation as they ascend until the molecules of the new complex gases can form clouds of vapor there forms an outer layer of radiating cloud matter such as we call the surface of the sun If the colder vapors, at this surface, are by any process drawn down or if by condensation they sink at a steady rate, they are again warmed up by compression, the descending gas becomes clear and may pass through the dissociation stages by absorbing a new quantity of heat radiated from the solar nucleus which heat is in turn to be lost by radiation in the subsequent ascension.

about an uniform temperature at all altitudes in the descending air. The fact that in high areas air is warmer as we descend down to a certain altitude must therefore be held to prove that the air is descending faster than this compensating rate, just as it does in the case of the föhn.

The resulting rate of warming expressed in degrees Centigrade per 100 meters of descent is given by the formula: one less the quotient of 288 divided by the rate of descent expressed in meters per day. Thus if the descent is 144 meters per day, the air will cool at the rate of 1°C. per 100 meters of descent; if the rate be 432 meters per day the air will be warmed up at the rate of 0·33° C. per 100 meters. In the upper layers of the maximum area of 1889, as investigated by Hann, the air grew warmer at the rate of 0·38° C. per 100 meters, corresponding to a rate of descent of 457 meters per day; on the other hand in the lower layer, namely between 500 and 1000 meters the air grew colder as the altitude diminished at the rate of 1·8° C. per 100 meters, corresponding to a rate of descent for the air itself of 103 meters per day.

(13) These figures must for the present be considered merely as illustrations of the quality of the influence that atmospheric radiation must exert on the temperature and motions of the air. If the coefficient of radiation of the upper air is less than Maurer's figure or if the coefficient for the lowest strata is as large as Hutchins' figures owing to the abundance of dust and haze, or if, as is generally the case the enclosure is more than 1° cooler, then the numerical rates just given will need to be modified. In either case the general principle remains that on the average throughout the whole atmosphere the cooling by atmospheric radiation largely compensates for the warming by compression and that in this way we must reconcile the hydrodynamic theories with the facts of observation so clearly set forth by Hann.

The compensating process here discussed is illustrated by the curves in the accompanying diagram which express the fact that if air starts at a height of 10,000 meters at P at a temperature of −50° C. and descend to the earth's surface adiabatically its temperature will be expressed by the straight line X and will be +50° C. on reaching the earth's surface. But if it cool by radiation its temperature at any altitude will be represented by such curves as A, B, or C, whose curvature will depend upon the rates of radiation and descent. The apices of these curves, or the regions where the increase of temperature with descent ceases and becomes a decrease, will be nearer the surface of the ground in proportion as the coefficient of radiation is smaller or the rate of descent is smaller and especially if the rate of descent diminishes with the time.



Temperature and Altitude.

These curves agree with the general tenor of all observations on the temperature of the air, namely that under a cloudy sky the diminution of temperature with ascent is very slight and uniform; within a cloud the diminution is given by the laws of evolution of latent heat; above all clouds and in all clear air as in areas of high pressure the temperature depends upon the radiation of heat and on the thermodynamic changes of a compressible atmosphere.

(14.) In addition to the cases recently under discussion between Ferrel and Hann there are other important problems in the mechanics of the atmosphere that are elucidated by the study of radiation.

(*a*.) The general circulation of the atmosphere from the equator to the pole can only take place by virtue of the fact that the air which overflows from the equator and from the tropical highs actually loses its heat (not merely diminishes in temperature) and contracts as it cools. Radiation is the only efficient process capable of accounting for the great loss of heat that the atmosphere experiences. Although we are not yet able to state the average amount and law of radiation as dependent on temperature and pressure yet it is easy to see that this must be known and must enter into our equations of condition before we can fully account for the phenomena observed in the general circulation of the atmosphere.

(*b.*) The passage of a steady atmospheric current over a mountain range depositing rain and snow on the windward side but descending as dry air on the leeward side gives rise to a standing wave such as may be seen above any obstacle in a rapid river. Thus kinetic energy is converted into static pressure and therefore on the leeward side under the summit of the wave down to the earth's surface there is a somewhat higher pressure than there would be in case no such current existed. The clear descending air by its dryness has also a slightly greater density than before at the same temperature and pressure which adds somewhat to the barometric excess. The cooling by radiation annuls approximately the warming by compression and again gives increased density. These three factors therefore conspire to increase the pressure at the earth's surface and this is again further increased largely by the influences of the earth's rotation and the southward flow as explained by Ferrel and Helmholtz. This is the best explanation that I have yet been able to frame of the formation of the high areas and cold waves that move southeastward over Canada and the United States. I believe that I first stated my conclusion as to this mechanism when, in 1876, I had occasion to urge the importance of maintaining meteorological stations in Alaska. The reports from these stations as subsequently established, as well as the international maps of the Signal Service, served to confirm that view. The original current on the Pacific side of the Rocky Mountains may be due either to a special cyclone or to the general circulation of the atmosphere resulting in a standing wave whose summit is over the Mackenzie River; when the current temporarily ceases, the summit and the high area die away; and when it is strongest, the high pressure is the greatest; generally the original current may be considered as a temporary overflow from northern Siberia along the arctic circle to Alaska.

Washington, March, 1892.

[P. S. As I finish this paper I perceive from the last number of the Meteorologische Zeitschrift that Dr. William Trabert of Vienna has repeated and confirmed Maurer's calculation of the coefficient of radiation. But the values (respectively 0·036 and 0·032 calories per hour per kilogram of air) thus deduced from meteorological observations cannot be preferable, as I have above stated, to the direct experimental determination. Trabert gives the values of the annual average temperature of the enclosure toward which radiation is supposed to have taken place during the night, which values are between 1 and 8 degrees Centigrade below the temperature of the radiating mass.]

ART. XLVI.—*Experiments upon the Constitution of certain Micas and Chlorites;* by F. W. CLARKE and E. A. SCHNEIDER.

SHORTLY after the publication of our first joint paper upon the constitution of the natural silicates,* we received from Mr. A. Lösch, curator of minerals in the Imperial School of Mines at St. Petersburg, some highly important material bearing upon our researches. Our work upon leuchtenbergite, it will be remembered, was defective, on account of impurity in the specimens at our disposal; and Mr. Lösch therefore sent us a supply of the perfectly pure mineral, selected with extreme care, and in the very best condition for study. To this gift he added four other minerals which he thought would be of interest to us, and upon these five specimens our present communication is founded.

The minerals, and the analyses are as follows:

A. Xanthophyllite, var. Waluewite, from the Nikolai-Maximilian mine, District of Slatoust, Ural.
B. Clinochlore from the same locality. Green, broadly foliated, closely resembling the mineral from West Chester, Pennsylvania.
C. Leuchtenbergite from Slatoust.
D. "Diallage serpentine" from the River Poldnewaja, District of Syssert, Ural.
E. White mica from Miask, Ural.

	A.	B.	C.	D.	E.
SiO_2	16·85	30·84	30·00	42·55	44·17
TiO_2	trace	----	----	----	----
Al_2O_3	42·33	18·31	20·43	1·25	37·35
Fe_2O_3	2·35	1·94	1·68	1·56	1·29
FeO	0·20	1·08	0·14	1·52	0·20
MnO	----	----	----	----	0·10
CaO	13·30	----	0·21	none	----
MgO	20·77	34·38	34·26	40·05	----
K_2O	----	----	----	----	10·00
Na_2O	----	----	----	----	1·14
Chromite	----	----	----	0·37	----
F	----	----	----	...	0·90
H_2O, 105°	0·04	0·55	0·55	0·21	1·06
" 250°–300°	0·12	0·49	0·35	0·11	0·53
" ignition	4·44	12·84	12·85	12·15	4·14
	100·40	100·43	100·47	99·77	100·88
Less O=F	----	----	----	----	·37
					100·51

*This Journal, Oct., Nov., and Dec., 1890.

The molecular ratios deducible from these analyses, rejecting water given off below 300°, and the chromite contained in the serpentine, are as follows:

	A.	B.	C.	D.	E.
SiO_2	·281	·516	·500	·709	·736
R_2O_3	·430	·192	·211	·022	·374
RO	·759	·874	·861	1·022	·004
R_2O	----	----	----	----	·124
H_2O	·247	·713	·714	·675	·230
F	----	----	----	----	·050

Hence we get the following empirical formulæ, in which all R‴=Al, all R″=Mg, etc.

Waluewite,	$Al_{86}Mg_{176}H_{60}(SiO_4)_{28}O_{174}$
Clinochlore,	$Al_{36}Mg_{87}H_{142}(SiO_4)_{52}O_{113}$
Leuchtenbergite,	$Al_{42}Mg_{86}H_{142}(SiO_4)_{50}O_{121}$
Serpentine,	$Al_4Mg_{102}H_{135}(SiO_4)_{71}O_{35}$
Mica,	$Al_{75}K_{25}H_{40}(SiO_4)_{74}O_9F_5$

The last of these minerals is evidently an ordinary muscovite, possibly a little altered, and will receive no further consideration in this paper. The other minerals were examined more in detail, with very interesting results. As in our previous work, all experiments upon each mineral were made upon a uniform sample of the powdered material, so that direct comparisons with the analyses might be possible. The analyses themselves agree closely with the published analyses made by others, and are noteworthy only in the fractional determinations of the water.

Towards dry, gaseous hydrochloric acid, at the temperature interval 383°–412°, the minerals under investigation were somewhat refractory. From the waluewite, after nine hours heating in the gas, only 0·22 per cent of lime and 0·10 per cent of magnesia were extractable by water. Hence we may fairly infer that the species contains practically no –Mg–OH groups, a result which is in accordance with theory, as will be seen later. The chlorites and the serpentine, however, gave anomalous results, as follows; there being two experiments on each.

	Clinochlore.		Leuchtenbergite.		Serpentine.	
Hours heated,	8½	13	16½	18½	28½	7
MgO extracted,	7·34	5·48	7·33	5·62	3·66	2·66

In each case the heating was continued to constant weight, but the amount of action was much less than in the American clinochlore and serpentines which we formerly investigated. The leuchtenbergite behaves much like the impure material

discussed in our earlier paper, from which 6·29 per cent of magnesia was removable; but more than double that amount is required to represent the MgOH which must be present under any recognized theory.

These results were so unsatisfactory that further work seemed to be desirable, but the tediousness of the process was discouraging. As a possible abbreviation of the method a new device was tried, which, although as yet unconclusive in its outcome, is nevertheless interesting. Ammonium chloride, as is well known, dissociates upon vaporization into ammonia and hydrochloric acid. Will it then, dissociating in presence of a silicate, act in any way by virtue of the acid so liberated? This question is still under investigation; but some preliminary data may here be given. In each experiment the mineral was intimately mixed with ten times its weight of sal ammoniac, and then heated in a platinum crucible, well below redness, until all the ammonium salt had been vaporized and driven off. The residue was then leached out with water, and the soluble magnesia determined. Upon olivine and waluewite there was very little action, as in the case of the treatment with gaseous hydrochloric acid; but upon the chlorites and serpentine there was a vigorous attack. The magnesia thus rendered soluble was as follows:

	Clinochlore.	Leuchtenbergite.	Serpentine.
Percent MgO,	2·12	3·98	4·93

In a second series of experiments the minerals were heated as before with ammonium chloride until the latter was driven off. Then a fresh charge of chloride was added to the contents of the crucible and expelled like the first. Finally a third charge was added and likewise expelled. By this means more magnesia was converted into chloride than in the first experiments, as the subjoined figures show:

	Clinochlore.	Serpentine.	
	3 heatings.	2 heatings.	3 heatings.
Soluble MgO,	3·80	14·30	10·63

The irregularities in all these data remain to be explained. So far the results have only qualitative value. In those minerals which must contain the group MgOH, some action takes place, but in variable amount. But the magnesium silicates which cannot contain MgOH are practically unattacked, and so far all the evidence is harmonious and clear. Contrary to our earlier expectations, however, we cannot trust the dry hydrochloric acid reaction quantitatively, at least until its conditions and its nature are more fully understood. We can determine when the group MgOH is present as an essential

part of a silicate, but not its actual amount. Probably the hydroxyl is first replaced by chlorine, converting the group –MgOH into the chlorhydrin-like group –MgCl. The latter, by continued action of the gaseous acid is then possibly split off as $MgCl_2$, but with secondary reactions to which the anomalous and irregular results may be due. The question is still open, and we hope by further experiments to get at something more conclusive. The problem is, to measure basic hydroxyl by its replacement with chlorine; and there seems to be no good reason why it should not be solvable.

By strong aqueous hydrochloric acid the chlorites and the serpentine were easily decomposed; but by previous ignition they were split up into soluble and insoluble portions. This splitting up is, in the case of serpentine, already well understood; the products being as Daubreé has shown, olivine and enstatite. For the waluewite and the chlorites, however, the existing data were scanty, and accordingly new experiments were undertaken. In each case the powdered mineral was ignited over a blast for several hours. It was then digested with strong hydrochloric acid, and after evaporation to dryness and re-solution, the residue was filtered off. Then, after drying and ignition, it was boiled with aqueous sodium carbonate to remove the silica which had been released from the soluble silicates, and the final residue was weighed and analyzed. As this process was followed in our first investigation with the Pennsylvania ripidolite, the results are included here for comparison with the Siberian material. The percentages of insoluble residue were as follows:

	Waluewite.	Clinochlore.	Leuchtenbergite.	Ripidolite.
Found,	45·01	17·56	19·24	19·74
Corrected,	43·96	16.63	18·05	18·49

In the second line the silica found in the residues, being presumably extraneous, is deducted. The composition of the residues is given below.

	Waluewite.	Clinochlore.	Leuchtenbergite.	Ripidolite.
SiO_2	2·34	5·25	6·16	6·32
R_2O_3	71·12	67·20	68·52	67·81
MgO	26·75	27·89	25·12	25·67
CaO	trace	----	----	----
	100·21	100·34	99·80	99·80

In these analyses the silica ranges from 0·93 to 1·25 per cent of the original mineral, and the remainder has quite sharply the composition of spinel. This point was noticed in our former paper, in the case of the West Chester ripidolite; but

since then it has acquired new significance, and it is emphasized by the new analyses. Leaving the waluewite for separate consideration, it is to be noted that the three chlorites studied by us are all typical members of Tschermak's orthochlorite series; which, according to him, are mixtures of two end compounds, serpentine and amesite. How amesite may behave upon ignition, we do not know; but serpentine splits up, as is well known, into olivine and enstatite; the latter being insoluble in hydrochloric acid. Under Tschermak's theory of the chlorites, a clinochlore of the composition SpAt, should upon ignition yield about 18 per cent of enstatite; or in other words, the insoluble residue should contain *at least* one third of all the silica in the mineral. Since no enstatite is actually formed, or practically none, it is plain that the three chlorites here considered contain no serpentine molecules; and hence, so far at least as these minerals are concerned, Tschermak's theory falls to the ground.

Approximately, but not exactly, the formation of spinel from the waluewite and the chlorites, seems to follow a single quantitative law. To illustrate this the empirical formulæ may be reproduced here.

Waluewite,	$Al_{56}Ca_{24}Mg_{52}H_{50}(SiO_4)_{28}O_{174}$
Clinochlore,	$Al_{28}Mg_{87}H_{142}(SiO_4)_{52}O_{113}$
Leuchtenbergite,	$Al_{42}Mg_{86}H_{143}(SiO_4)_{50}O_{121}$
Ripidolite,	$Al_{38}Mg_{86}H_{140}(SiO_4)_{50}O_{113}$

Upon ignition, of course, water is expelled, and the ignited residue is empirically as follows:

Waluewite,	$Al_{56}Ca_{24}Mg_{52}(SiO_4)_{28}O_{142}$
Clinochlore,	$Al_{28}Mg_{87}(SiO_4)_{52}O_{41}$
Leuchtenbergite,	$Al_{42}Mg_{86}(SiO_4)_{50}O_{43}$
Ripidolite,	$Al_{38}Mg_{86}(SiO_4)_{50}O_{43}$

Here we have in each mineral an excess of oxygen over SiO_4, and to that excess the amount of spinel residue is approximately proportional, thus:

	Found corrected.	Calculated.
Waluewite,	43·96	43·15
Clinochlore,	16·63	14·80
Leuchtenbergite,	18·05	17·62
Ripidolite,	18·49	15·83

Considering the impurities in the original materials, and the unavoidable inaccuracies of manipulation, the agreement here is as close as could be expected. The calculation assumes that the excesses of oxygen represent quantitatively the amount of spinel formed, and all the errors of analysis are accumulated in

the final result. If we deduct the spinel from the composition of each mineral, the soluble portion is expressible as a mixture of olivine and magnesian garnet; two species which are among the commonest progenitors of the chlorite group. That olivine and garnet are actually formed is certainly not proved; but it seems highly probable that the chlorites studied do split up in the manner indicated, yielding water, spinel, garnet and olivine as the final products of decomposition. Other chlorites may behave differently; and it is quite likely that the species or varieties rich in iron may diverge widely from the types considered here. Speculation upon this theme would be premature.

As to the chemical structure of the leuchtenbergite and clinochlore, the evidence now available is quite in harmony with the general theory of the chlorite group recently advanced by one of us.* Again including the Pennsylvania ripidolite, the three chlorites reduce to compositions as follows:

Clinochlore,	$Mg_{60}(SiO_4)_{52}(AlH_2O_2)_{38}(MgOH)_{37}H_{30}$
Leuchtenbergite,	$Mg_{49}(SiO_4)_{50}(AlH_2O_2)_{42}(MgOH)_{37}H_{22}$
Ripidolite,	$Mg_{49}(SiO_4)_{50}(AlH_2O_2)_{38}(MgOH)_{37}H_{27}$

Condensing, by union of the univalent factors, these become—

Clinochlore,	$Mg_{60}(SiO_4)_{52}R'_{105}$
Leuchtenbergite,	$Mg_{49}(SiO_4)_{50}R'_{101}$
Ripidolite,	$Mg_{49}(SiO_4)_{50}R'_{102}$;

or, in general, all three examples have nearly identical composition, and conform to the typical expression—

$$Mg_2(SiO_4)_2R'_4,$$

in accordance with the theory which represents them as substitution derivatives of the normal salt $Mg_4(SiO_4)_2$. We may interpret the minerals in detail as was done in the case of our earlier discussion of the West Chester ripidolite, or we may regard them as mixtures of the two salts—

$$Mg_2(SiO_4)_2(AlH_2O_2)_2(MgOH)_1H$$
$$\text{and } Mg_2(SiO_4)_2(AlH_2O_2)_1(MgOH)_2H$$

In either case the juxtaposition of the groups AlH_2O_2 and MgOH renders the formation of spinel intelligible.

In the waluewite, or more properly xanthophyllite, we have the first example of a true brittle mica met with in the course of our investigations. Being the most basic known member of the clintonite series, it has peculiar interest; and it deserves a somewhat detailed discussion. In the empirical formula deduced from our analysis,

* This Journal, March, 1892.

$$Al_{56}Ca_{24}Mg_{52}H_{50}(SiO_4)_{28}O_{174},$$

the most noticeable feature is the great excess of oxygen compared with the possible hydroxyl and the small amount of SiO_4. This excess is accounted for in part by the general formula which we have heretofore assigned to the clintonite group,

$$\begin{matrix} & & O & \\ & & \diagup & \diagdown \\ Al & - & O & > R'' \\ & & \diagdown & \\ & & SiO_4 & - R'_2; \end{matrix}$$

which formula, however, needs some extension along a new line. In that formula the group of atoms $-AlO_2R''$ appears, an equivalent obviously of the group AlO_2H_2; and this group may fairly be repeated among the components of R'_2. With such a group, the extreme member of the clintonite series should have the composition $(AlO_2R'')_4SiO_4$; and a molecule of that type is theoretically capable of splitting up into olivine and spinel in the ratio of 1:2, when each mineral is given its lowest possible formula:

$$(AlO_2R'')_4SiO_4 = R''_2SiO_4 + 2R''Al_2O_4$$

In the case of xanthophyllite, if such a molecule is contained in it, the olivine formed should be partly monticellite. At Monzoni, monticellite is found associated with spinel; and brandisite, a member of the clintonite series, occurs in the same region. In fact, all three of the true clintonite micas are commonly associated with spinel, a fact of much interest when considered in its relations to our experiments. In the light of the foregoing argument the composition of waluewite and its manner of decomposition by heat, may be represented as follows:

$$\begin{matrix} & & O & & & & O & \\ & & \diagup & \diagdown & & & \diagup & \diagdown \\ 5Al & - & O & > Ca & & + 5Al & - O & > Mg \\ & & \diagdown & & & & \diagdown & \\ & & SiO_4 & - H_2 . AlH_2O_2 & & & SiO_4 & - (AlO_2Mg)_3 \end{matrix}$$

$$+ 1Al \begin{matrix} \diagup O \diagdown \\ - O > Ca \\ \diagdown SiO_4 \end{matrix} (AlO_2Ca)_3$$

These three molecules are all of the general type heretofore assigned to the clintonite series, and two of them are presumably capable of yielding spinel. Reducing the original analysis to 100 per cent with consolidation of like bases as usual, we get the following comparison between experiment and theory; the calculated composition being in accordance with the structural formula above cited.

	Found, reduced.	Calculated.
SiO_2	16·97	17·02
Al_2O_3	44·14	44·71
CaO	13·50	13·00
MgO	20·92	20·63
H_2O	4·47	4·64
	100·00	100·00
Spinel formed,	43·96	43·94

Reckoned on a similar basis, clintonite, according to the analysis published by Sipöcz, may be written—

$$AlO_2R''.SiO_4.H_2+(AlO_2R'')_4.SiO_4$$

and brandisite is of the same general character, with a small admixture of the first of the three xanthophyllite molecules given in our structural expression. Whether chloritoid is a true member of this group, seems to be uncertain; but if it is, its composition may be written $AlO_2Fe.SiO_4.H.AlOH$; the last factor being a bivalent group related to the univalent AlO_2H_2.

As for the ultimate structure of the group AlO_2R'', it may be written in two ways, thus:

$$-Al<\begin{matrix}O\\O\end{matrix}>R'' \text{ or } -R'-O-Al=O$$

The first form corresponds to the group $-Al(OH)_2$, the second to the formula commonly assigned to spinel,

$$Mg<\begin{matrix}O-Al=O\\O-Al=O\end{matrix}$$

In either case two of the groups AlO_2R'' coalesce to form one molecule of spinel, with removal of a single magnesium atom. Such a coalescence is easiest comprehended when the second form of the radical is chosen; but the first form is more harmonious with the constitution of the mica series in general. If the xanthophyllite compound $(AlO_2R'')_4SiO_4$ be regarded independently of the micas, it is most simply written as follows, with its splitting up into olivine and spinel as indicated:

$$Si<\begin{matrix}O-Mg-O-Al=O\\O-Mg-O-Al=O\\O-Mg-O-Al=O\\O-Mg-O-Al=O\end{matrix} \qquad Si<\begin{matrix}O\\O\end{matrix}>Mg \quad Mg<\begin{matrix}O-Al=O\\O-Al=O\end{matrix}$$

$$Si<\begin{matrix}O\\O\end{matrix}>Mg \quad Mg<\begin{matrix}O-Al=O\\O-Al=O\end{matrix}$$

If, however, for the sake of preserving harmony with the mica formulæ we adopt the first expression for $-AlO_2R''$, then spinel would seem to have the constitution

$$Mg<\begin{matrix}O\\O\end{matrix}>Al-O-Al=O$$

Although the last formula is somewhat novel, it is not altogether improbable; but between it and its alternative we cannot yet certainly decide. Another open question is furnished by the chlorites, in which the formation of spinel may possibly be due to the presence of AlO_2Mg groups. Upon this supposition, however, the chlorites do not reduce to simple formulæ, and therefore the suggestion has slight value. Apart from all theoretical considerations, the spinel reaction, as it may fairly be called, is one of an entirely new order in mineral chemistry, and it opens up a noteworthy line of attack upon the difficult problems before us.

Laboratory U. S. Geological Survey, Washington, Jan. 14, 1892.

ART. XLVII.—*On the Qualitative Separation and Detection of Strontium and Calcium by the Action of Amyl Alcohol on the Nitrates;* by P. E. BROWNING.

[Contributions from the Kent Chemical Laboratory of Yale College, XIII.]

IN a recent paper* I have shown that strontium and calcium may be separated quantitatively by boiling the nitrates of these elements with amyl alcohol and applying the corrections determined for the solubility of the strontium salt. The qualitative separation, however, is somewhat vitiated by the deposition of a slight residue upon the bottom of the test tube or beaker when calcium nitrate is boiled with amyl alcohol. While this deposit weighs but a few tenths of a milligram and is insignificant in its effect upon the interpretation of the quantitative results, it may easily be mistaken for strontium in the qualitative test unless tested spectroscopically. This residue when dried, dissolved in water and nitric acid, and again treated with amyl alcohol is not dissolved completely but again separates out wholly or partially. The possibility of the formation of the calcium salt of an organic acid by the action of the nitric acid on the amyl alcohol (a point to which reference was made in the paper before mentioned), suggested the idea that ignition might so change the residue that it would not re-appear upon a second boiling with the amyl alcohol. Experiment proved the truth of this presumption; for it was found that after getting the ignited residue into solution with water and a drop of dilute nitric acid, subsequent boiling with amyl alcohol effected complete solution, as shown by experiments (1), (2), (3), (4) of Series I below. In applying the method qualitatively, small amounts of the amyl alcohol may be conveniently used and the boiling carried on in a test tube, care being taken

* This Journal, vol. xliii, p. 50.

to keep the inflammable fumes of the alcohol from the flame. Five cubic centimeters of the alcohol is a convenient amount to use in each boiling and the error introduced by the solubility of the strontium salt is thus reduced to a minimum, the solubility in 30cm³ having been determined to be 0·001 grm. of the oxide. Experiments made to test the delicacy of the method as regards the detection of strontium alone are recorded in Series I (5), (6), (7), (8), (9); and (10), (11), (12), (13), give the results of the treatment in the presence of both strontium and calcium. Into a test tube is put the mixture of the nitrates of strontium and calcium not exceeding 0·2 grm., that being the limit of the solubility of calcium nitrate in 5cm³ of amyl alcohol. After dissolving in a few drops of water 5cm³ of amyl alcohol are added and the boiling is carried on until the normal boiling point of the alcohol, 128–130° C., is reached. If strontium is present to the amount of 0·001 grm. of the oxide or more a very decided separation takes place. If the amount is smaller it cannot be readily distinguished from the residual spots deposited on the bottom of the tube by the calcium salt. The alcohol containing the calcium salt dissolved is decanted upon a dry filter paper in a dry funnel and the residue washed in the tube with about 5cm³ of absolute ethyl alcohol, this also being filtered into the tube containing the amyl alcohol. The filtrate is reserved to be tested for calcium, while the residue, if so small that it may be a calcium deposit, is dried gently and finally ignited by agitating the tube over a flame. After cooling the tube a few drops of water and a drop of nitric acid are added and the boiling repeated. As the results of Series I show, any amount of strontium above 0·0005 grm. of the oxide separates out distinctly, while the slight calcium residue does not reappear. My experience has been that amounts of calcium nitrate equal to 0·2 grm. give a deposit on the first boiling about equal to 0·0003 grm. of strontium oxide on the first boiling. The residues from the second treatment in Series I (5) to (13) were all dissolved in a few drops of water treated with a drop of hydrochloric acid and tested before the spectroscope, all giving distinct strontium lines but no trace of calcium. The calcium residues from the first boiling gave distinct calcium lines but no trace of strontium.

The delicacy of the process in the detection of calcium is shown by the experiments of Series II. The method of treatment was the same as described above excepting that the filtrates and washings after the first boiling were used for these tests. To these clear filtrates about 2cm³ of dilute sulphuric acid were added, and in five minutes or less the results recorded were apparent. When strontium alone was taken either in

large or small amounts, the result was uniformly a faint cloudiness gathering after standing sometime to a minute precipitate of a granular character. In the case of the calcium the detection could be carried easily to 0·0005 grm. of the oxide, and satisfactory results were obtained with 0·0002 grm. The character of the precipitate in the case of calcium was moreover, distinctive, it being in every case light and flocky, and collecting in floating masses. With the precautions noted very satisfactory results can be obtained by this method, not the least advantage being the rapidity with which a determination can be made. It will be noticed that in some cases calcium and strontium are recorded as the nitrates and in others tabulated as oxides. When either strontium or calcium were used in large quantities the pure nitrate was weighed out directly; when very small amounts were used these were taken from the standardized solutions of the nitrates used in the quantitative work, the standards of which had been recorded in terms of the oxide. The strontium and calcium salts used in this work were specially purified by the methods detailed in my previous paper.

SERIES I.

	SrO taken.	$Ca(NO_3)_2$ taken.	Deposit after 1st boiling.	Deposit after 2nd boiling.
(1)		0·1 grm.	Trace.	None.
(2)		0·2 "	Slight.	None.
(3)		0·2 "	Slight.	None.
(4)		0·2 "	Distinct.	Faintest trace.
(5)	0·0003 grm.		Faint trace.	Faint trace.
(6)	0·0003 "		Faint trace.	Faintest trace.
(7)	0·0005 "		Distinct.	Distinct.
(8)	0·0005 "		Distinct.	Distinct.
(9)	0·0010 "		Distinct.	Distinct.
(10)	0·0010 "	0·2 "	Distinct.	Distinct.
(11)	0·0005 "	0·1 "	Distinct.	Faintest trace.
(12)	0·0007 "	0·1 "	Distinct.	Faint trace.
(13)	0·0008 "	0·05 "	Distinct.	Distinct.

SERIES II.

	$Sr(NO_3)_2$ taken.	CaO taken.	Result.
(1)	0·001 grm.		Faint granular cloudiness.
(2)	0·1 "		" " "
(3)	0·2 "		" " "
(4)		0·001 grm.	Decided flocky floating masses.
(5)		0·0005 "	" " " "
(6)		0·0002 "	" " " "
(7)		0·0001 "	Plain " " "
(8)		0·00005 "	Faint " " "
(9)	0·1 "	0·0005 "	Decided " " "
(10)	0·1 "	0·0002 "	" " " "
(11)	0·1 "	0·0001 "	Plain " " "
(12)	0·2 "	0·0002 "	Decided " " "

ART. XLVIII.—*The Age and Origin of the Lafayette Formation;* by EUGENE W. HILGARD.

THE interest so widely felt in the Lafayette formation since its great extension northward has been definitely established and its details in that region studied by Mr. W. J. McGee, and described in other special communications on the subject which have reached me, suggests the timeliness of a summary presentation of my views, as shaped under the light of a fuller view of the whole formation and a review of the matter in the Mississippi Embayment during the past summer, by a party of geologists. This party included, besides Mr. McGee and myself, Professors Safford of Tennessee, Smith of Alabama, Holmes of North Carolina, and Lester F. Ward and R. T. Hill of the U. S. Geol. Survey.

As the publications containing the record and discussion of my former observations (in which the formation carries the name of "Orange Sand," now dropped by agreement) are difficult of access after the lapse of from twenty to over thirty years, it may be necessary to recapitulate, summarily, the main points as then presented, in order to render the later discussion intelligible to all interested.

The eastern outline of what I have called the "Orange Sand Delta" extends from a point near Cairo, through western Kentucky and Tennessee, nearly through the northeast corner of Mississippi into Alabama; whence, as I then ascertained from the descriptions of Tuomey, and by correspondence with Dr. Joseph LeConte, it passes eastward around the Appalachian highlands into the Carolinas and thence north to Virginia and Maryland. On the west, I traced the formation by D. D. Owen's descriptions through Arkansas, and personally through Louisiana and across the Sabine into Texas.

Within the limits given, say between the Warrior river on the east and the Sabine on the west, and excepting the areas occupied by the Cretaceous prairies, the (Tertiary) "Flatwoods," the Loess, and the Mississippi bottom, the formation as a rule lies at or near the surface of the country, most frequently covered by a few (three to ten) feet of brown or yellow loam of much later date, since it also overlies the Loess. The characteristic concretionary ferruginous sandstone of the formation (replaced occasionally by a white siliceous sandstone or chert) caps nearly all the higher ridges, the crests of which it has protected from degradation, and usually forms the upper portion, or sometimes the entire body of such ridges; showing, by their alternation with others bearing only a thin cap of the

"Orange Sand," that the latter has been deposited on a deeply denuded surface. The latter fact is also shown in numerous profiles, and is the rule in the interior uplands; while near the larger river troughs, and notably in a north-and-south direction, the unconformity is less conspicuous and the lower limit of the formation is less uneven. In the southern portions of Mississippi and Louisiana, the rolling plateaus that bear the great long-leaf pine forest, are underlaid by the formation sometimes to the depth of over 200 feet. It reaches the Gulf shore at only a few points; in Mississippi near Shieldsboro', where prominent ridges abut on the coast plain on Pearl river about 20 miles above its mouth. In Louisiana the shore is reached at the Island of Petite Anse, where it immediately overlies the (doubtless Cretaceous) rock-salt deposit. Within the last few years it has been proved to reach the shore of Mobile Bay, by Lawrence Johnson.

The material of the formation, away from large channels and from contact with underlying beds, is predominantly a ferruginous (sometimes more or less clayey), hence usually orange or rust-colored, but sometimes purplish, white or variegated sand, consisting almost entirely of quartz grains much rounded and smoothly polished, and very commonly incrusted with the rusty pigment. This external character of the sand is popularly so well understood that building contracts expressly provide for "river or creek" sand, prohibiting the use of that formed of the smooth, round grains for mortar. Near the surface of the formation this sand is commonly more or less commingled with the surface loam or its washings; while where it overlies clayey formations of whatever age, it is commonly more or less commingled with similar clays (more or less altered), whether by inter-bedding, intermixture, or very commonly by the inclusion of rounded clay fragments, ranging in size from mere grains to bowlders of a foot or more diameter. Where in contact with sandy formations, the lower portions of the "Orange Sand" (identified as such by the peculiar bedding, and unconformity with the underlying older beds), commonly consists of the materials of such beds, re stratified in the manner of the later formation.

Near the great river channels, notably that of the Mississippi on either side, on the Tombigbee and Tennessee, as well as on the Sabine, there is a steady increase of gravel; shown conspicuously on the landward margin of the Loess belt of the Mississippi, as well as, at numerous points, close to the river itself; and (near the line between the states of Mississippi and Louisiana) eastward to Pearl river and Lake Pontchartrain. Conspicuous gravel deposits lie along the lower course of the Tennessee river, in Mississippi and Tennessee.

The *substance* of this gravel is by far predominantly chert of Subcarboniferous age, less frequently siliceous sandstone and quartzite; but the corals and crinoids, as well as occasionally the trilobites of the older Paleozoic rocks are always more or less represented. No calcareous rocks have been found anywhere; but in and near the main channel of the Mississippi, pebbles of crystalline rocks—granite, syenite, gneiss, mica-schist, as well as dioritic greenstone and eruptives—are not uncommon, though always much rounded, usually small but occasionally of several pounds weight, and usually also much decayed. A similar assortment of crystalline rocks was observed by me at Petite Anse island, on the Gulf shore, in the direct line of the axis of the Mississippi valley.

While the *size* of the pebbles commonly ranges from that of a walnut to that of a fist, there occur occasionally bowlders of considerable weight, up to several hundreds of pounds, of the same rock material as the smaller gravel.

The *structure* of the formation is extremely irregular. It may broadly be said to be approximately horizontally bedded or stratified, without having any well-defined general dip, save in that it conforms to that of the general surface of the country to southward. In its upper portions it is sometimes wholly structureless in profiles of as much as twenty feet, when the material is usually somewhat clayey and constitutes a sandy loam. Most commonly however the bedding-lines are conspicuous and very complex, showing the flow-and-plunge structure of sand-bars, often alternating with that of beaches, and then again, particularly on the more consistently continuous stratification lines, the peculiar wavy structure which belongs to the flood-deposits of valleys. The bedding and stratification lines are commonly conspicuously marked by the ferruginous coloring which pervades more or less the whole formation and doubtless forms an important landmark in its history.

In this irregularity of stratification and bedding the formation differs pointedly from the bulk of the Tertiary formations that have preceded it on the same areas; although locally, cross-bedding occurs in these as in all formations of sandy materials. But in the Lafayette beds the structure resulting from deposition in flowing and violently agitated waters is all but universal.

In its *stratigraphic relations* to other formations the "Orange Sand" of the Mississippi embayment shows a prevalent unconformity with both the older and later beds with which it is in contact. It has been deposited on a deeply eroded or sculptured surface, and has itself suffered deep erosion before the deposition of the succeeding deposits. Yet inasmuch as in its formation it has largely drawn upon the materials of the subjacent beds, apparent conformity frequently exists where these

are sandy; while complete and unquestionable unconformity may be exhibited in the next ridge, where the subjacent beds are indurated or clayey. Similarly, apparent conformity exists very commonly along the Mississippi river, between the upper member of the Lafayette and the Loess and Port Hudson—the "Columbia" of McGee. But inland the most striking unconformities may be seen in abundance, proving the reverse condition to be accidental.

As regards its *geological age*, since it overlies the latest recognized Tertiary (the Grand Gulf beds) and is in turn overlain by the earliest recognized Quaternary of the region (the Port Hudson), the Lafayette may, *a priori*, be claimed for either of the two subdivisions; being (in the "Orange Sand" facies at least) entirely devoid of fossils that can with certainty be claimed as its own, although containing abundance of borrowed ones.

Considering the conspicuously detrital nature of the materials, the predominantly "fluvial" structure, and the total absence of any traces of contemporary marine fossils, even close to the shores of the Gulf and in materials perfectly adapted to their preservation: it has seemed to me most probable that the formation as a whole is the outcome of the action of "fresh water in the state of violent flow." At the geological level we must attribute to the "Orange Sand" at least—the latest Tertiary or the earliest Quaternary—the melting of the continental glacier naturally suggested itself to my mind as well as to that of Tuomey, with whom I discussed the subject in 1856. This suggestion acquired especial force by the fact that crystalline bowlders, apparently identical with those occurring in the moraines of Illinois and Missouri, occur in the main axis of the embayment down to the Gulf shore, where the current-velocity would presumably be greatest; while outside of that great axis only the local rocks, or those not derived from any great distance at least, form the bulk of the gravel deposits. I was thus led to consider the "Orange Sand" as the direct representative and continuation southward of the "stratified drift" of the Northwest, and have alternatively so designated it in my later publications.

Such was, summarily, the condition and aspect of the subject when, nearly twenty years ago, the stoppage of the Mississippi Geological Survey, and my removal from the Southwest, put an end to my personal researches in the premises. The matter has passed into several text-books in that form; and the only important change made until McGee, a few years ago, approached the subject from the eastward, was the recognition by Dr. Eugene Smith of Alabama of the lower portion of the Warrior gravel beds as belonging to old Cretaceous or

even pre-Cretaceous time, while with me he still considers the upper portion of the "Tuscaloosa" as being the same materials re-arranged by aqueous agencies during the "Orange Sand" or Lafayette epoch. This discovery changes the general aspect of the latter formation in so far as I had attributed the heavy gravel deposits of the Tennessee and Warrior river borders to strong currents coming from the northward—as indicating the course of the easternmost delta-bayou of the glacial flood; while from the point of view that these gravels are merely debris torn from the ancient sub-Cretaceous beach formed almost on the site of the parent rock-formation (the Subcarboniferous chert), the assumption of any such large current flowing to southward in that region becomes unnecessary. In fact, it becomes possible that even the older border gravels of the Tennessee river may have traveled in the reverse direction, down the present Tennessee valley; and we gain an insight into the origin of the enormous gravel masses of that region without resorting to any violent hypotheses concerning events in Quaternary time.

Another point involving a former error of interpretation on my part is the recognition of the Cretaceous age of the lower portion of the profile at the "Big Hill" near Pocahontas, Tenn., that in my report of 1860 (p. 16) is figured and described as a conspicuous "Orange Sand" locality. Now that the rains of thirty-five years have sculptured the smooth sides of the original cut, it is easily seen that the lower portion is not of the Lafayette character, and that the clay basin then supposed by me to contain here, at least, vestiges of the Lafayette flora, is therefore referable to a time anterior even to the Tertiary; probably the Ripley Cretaceous.

It would seem natural and logical to seek for the record of changes of level concerning the Mississippi valley—the great central drainage basin of the continent—in the border lands of the Gulf into which this drainage passes; but for years I have sought in vain to impress this point of view upon those in whose hands lay the power for initiating such researches. It thus happens that prior to the time when McGee's researches carried him into the field where I had previously worked, the discussion of the continental changes of level was carried on by geologists working at the head of the great valley, largely irrespective of what is recorded near the only datum-plane to which such oscillations can legitimately be referred; since the Archæan highlands of the northeast form a pivotal area from beyond which no reasonable conjectures can be translated, the Mississippi axis being known to be a line of weakness and unstable equilibrium, whose movements have been largely independent of those of the Atlantic coast. Witness the peculiar develop-

ment of the Cretaceous and Tertiary formations in the Mississippi embayment.

I think that many if not most of the differences which have arisen between McGee and myself in the interpretation of the phenomena of the Lafayette formation have been due to the different starting points. McGee, coming from the Atlantic coast, naturally carried the views acquired there into the territory where, I am inclined to think, a materially different mode of development has occurred; as would naturally be expected in so critical a region. The joint reconnoissance made last summer has, I think, materially diminished these differences of views; and the extension of this reconnoissance around the Gulf shore into Mexico by himself and party will, I hope, prove the fruitful first step toward the final unraveling of the complex questions which, alone, I was powerless to solve.

Broadly speaking, the difference of views referred to may be summarized in this, that while McGee regards the whole of the Lafayette formation as having been formed under a condition of continental depression and marine submergence, I have on the contrary, referred the origin of the "Orange Sand" of the Embayment to a period of elevation, and the deposition of its materials essentially to fresh water in the form of broad and shallow floods coming in from the northward and practically devoid of organic life of which the remains would be likely to be preserved. All are, however, agreed that the deposition, by whatever agency, was succeeded by a relatively long period of elevation or at least emergence, during which subaërial exposure brought about both the surface sculpture and the condition of complete peroxidation, and leaching of all water-soluble ingredients, that is so prominent and essential a feature of the "Orange Sand" phase of the formation. For within its beds, nothing that is capable of further oxidation or water-solution remains, so that agriculturally the formation, alone, is about as barren as can well be.

That the paludal nature of the overlying Port Hudson beds, as well as the fluvial and calcareous nature of the Loess, necessitates the assumption of a subsequent re-depression, need hardly be more than mentioned. The extent of this oscillation I will presently consider.

It would seem from the character of the formation as observed on the Atlantic coast, that the evidence of long emersion and subaërial exposure is not so cogent there. Certainly the leaching process, as well as that of ferrugination, has not been carried so far as is the case in the Embayment, since according to McGee, the gravels still contain rare calcareous pebbles; of which, as before stated, not a trace remains in the "Orange Sand," although limestone formations are plentiful

both in and around its area of occurrence. I am not however, prepared to discuss the eastern phase of the formation, of which I know merely generalities. From statements made by McGee I infer that there are wide and material differences in the maximum elevation at which the formation is found at various points around the Appalachian highlands; the data thus far published by him are not sufficient for an outside discussion of this point.

In the Embayment itself, some questions arise in regard to the identity of the formation as a whole, since McGee inclines to consider as belonging to it a lower phase of "plant beds" which I have always regarded, and do still regard, as belonging to the subjacent formations of various ages. Nothing that I have seen during the late joint reconnoissance seems to me to justify a change of opinion on my part in this respect; I have now as formerly seen the lignitiferous beds of the several stages of the Tertiary, from the lowest Eo-lignitic to the Grand Gulf, underlying the characteristic transition beds of the "Orange Sand;" but I hope to be able to set this question at rest by a microscopic examination of the specimens collected. If there is any true "Lafayette" plant bed, it should be possible to identify it at the various points of occurrence; which to my mind, however, exhibit simply contact phenomena. Prof. Ward's paleobotanic researches, also, will I hope be brought to bear on this question. I understand, however, that McGee does not claim such a plant bed as an integral part of the Eastern phase of the formation. Its existence would not necessarily conflict with either his or my views of the origin of the Lafayette sands.

One of the most vital points to be settled by closer investigation than has yet been made is the exact correlation of the gravel deposits. From their apparent continuity I have referred to the Lafayette age most of the larger gravel beds of the interior and river border, distinguishing only those manifestly belonging to the surface loam, and certain limited deposits within the Port Hudson beds. McGee has shown that small gravel beds do occasionally occur at the base of the Loess itself; and a late detailed examination of the instructive profile at Natchez proved, to the satisfaction of all of the exploring party, that even considerable gravel beds do occur within what, from all characters, must be presumed to be Port Hudson beds. Within these I found several small crystalline (gneissic and mica-schist) pebbles; but it was in a bed of ferruginous gravel conglomerate of some 25 feet thickness, underlying the typical Port Hudson and reaching below water level, that an abundance of crystalline pebbles, and cobbles up to three and four pounds weight, were found. It was proba-

bly from the same locality, as well as from the gravel beds at Proffit's island, below, that the collection of such gravels, formerly at the capitol at Jackson, Miss., that was destroyed during the war, were obtained. The ledge of ferruginous gravel conglomerate is underlain (as seen at the landing a mile above) by a bluish clay of the peculiar aspect and texture of the typical Grand Gulf Tertiary, which is everywhere else overlain by the Lafayette. We thus appear to have in the Natchez profile the usual regular sequence, in full, of Grand Gulf, Lafayette, Port Hudson beds with calcareous nodules, "Sand Loess," calcareous (typical) Loess, and brown surface loam.

It has seemed to me, from the outset, but natural that the larger crystalline gravel, coming from beyond the barrier of Carboniferous rocks above Cairo, should remain within a short distance of, or entirely within, the deep central channel which has always coincided closely with the Mississippi trough of to-day; while the flood waters carrying the lighter gravel and sand would spread over the uplands, laterally, where afterwards, by long subaërial exposure, the small crystalline gravel would disappear completely by weathering, as indicated by the very "rotten" condition of the same class of gravels at Natchez and Proffit's island. To my mind it would be rather surprising if such pebbles had survived up to this time in the upland or lateral portions of the Lafayette deposits; it greatly surprised me to find them as far south as Petite Anse, for although small and much decayed, there still were some of several ounces weight. I do not therefore see that the absence of crystalline moraine gravels from the lateral portions of the Lafayette in Tennessee, Mississippi and Louisiana, even if as complete as has been thus far supposed, has the weight assigned to it by Chamberlin and Salisbury (this Journal, xli, 359, who contend that on that ground alone the formation must be referred to a period preceding the glacial epoch—inferentially, the Tertiary; the same observers having found the loess to contain essentially the materials of the Illinois moraines, while the gravels which they consider as contemporaneous with the "Orange Sand" and which they find to reach as far up as Keokuk, are free from such material and are evidently preglacial. On the other hand, Call, in his discussion of the formations of Crowley's ridge in Arkansas, refers certain gravels found there to Quaternary time and identifies "Hilgard's Orange Sand" with underlying deposits in which he finds unquestionable evidence of Eocene age. He is clearly mistaken as to the nature and identity of the much-discussed formation so designated by me; which as he should have

known, overlies the latest Tertiary of the Southwest, the Grand Gulf.

The concrete question whether the Natchez gravel, bearing crystallines, is continuous with, and equivalent to the abundant gravel beds of the adjacent uplands, should be solvable without any serious difficulty by direct tracing along the deep ravines and valleys that run at right angles to the river at and below Natchez; and the same can, doubtless, be done at most other points on the Mississippi River. But it must be done by those who can be relied upon not to confound accidental continuity with that which is essential. It is clear that here as in the case of the Warrior or Tuscaloosa beds, a very critical judgment must be exercised; since one and the same gravel may have been "worked over" several times during successive geological epochs, and it must often be extremely difficult to discriminate between that which is essential to the origin and composition of the deposit, and that which is a local accident.

Pending the determination of this point in the field, and possibly with the aid of further microscopic research on the samples already collected, I call attention to the fact that intrinsically, the discussion of the "Tertiary" or "Quaternary" age of the Lafayette may easily be more a war of words than of essentials. If preglacial, as is maintained by McGee and Chamberlin, it certainly stands at the very top of the Tertiary series, if the beginning of the Glacial period be made the criterion of the lower limit of the Quaternary. But this is a purely arbitrary limit. It is quite certain that the conditions under which, from any point of view, the Lafayette was deposited, differed widely from those which presided over the formation of all the other Tertiary stages in the Southwest. During early Eocene times there prevailed in the upper portion of the Embayment, estuarian, marsh and paludal conditions, as is evidenced by the lignitiferous beds of that region. Later we find steadily increasing marine conditions, represented by the Claiborne, Jackson and Vicksburg terranes: at the end of the latter epoch the Embayment had already lost so much of its northward extension that the Gulf shore was only slightly more convex than at present. Then comes the somewhat enigmatical Grand Gulf terrane, clearly a brackish water deposit, consisting largely of remarkably solid clays and (usually) very soft and more or less clayey sandstones. Of recognizable fossils this formation contains only plants, so far as has been definitely ascertained; but certain calcareous beds within it seem to contain the macerated, concretionary remnants of a molluscan fauna, such as are now found over the greater portion of the Port Hudson terrane, but which at some points differentiate, into well defined fluvio-marine shells.

While the Grand Gulf beds thus indicate a predominance of fresh-water conditions for which the end of the preceding (Vicksburg) epoch has not prepared us, yet it follows the older Tertiaries in that it offers no evidence of any other than quiet modes of shore and marsh sedimentation, undisturbed, so far as we have seen, by any invasion of fluvial conditions. Cross-bedding even is unusual, and what there is is clearly of the kind induced by wave action; gravel is almost foreign to the formation, although sometimes seen near the axis of the Embayment. At the end of the Grand Gulf epoch the Embayment had practically ceased to exist; the northern Gulf-shore line was almost exactly parallel to the present one, and all this had been done in a quiet, systematic, orderly way, during a slow upward movement of the land.

With the next succeeding formation, the Lafayette, there is a total change both in the material and its mode of deposition, preceded by deep erosion of the surface of the older formations. So far from continuing the advance of the shore-line into the waters of the Gulf of Mexico, we suddenly have (according to McGee's views) the latter advancing at least to the head of the Mississippi Embayment, and according to Chamberlin, clear up to Keokuk, by a general depression. But this general depression does not carry marine features backward over the land; on the contrary, while not a marine fossil, even in the most "demoralized" condition, can be found in the entire enormous area covered by the formation, we have a marked increase in all features that we habitually look for in a fresh-water, fluvial formation; including the evidences of violent currents, with a total absence of beach lines to show either the advance or recession of the supposed submergence. The only evidence that might be thus construed are the gravel beds; but as these run in the main *parallel* to the axis of the Embayment, while according to the Tertiary régime they should run *crosswise;* and since in the very axis of the Embayment the material of these gravels gives evidence of transportation from north to south, on a slope materially greater even than exists at the present time: it seems to me very difficult to construe the gravel beds into beach shingle.

It seems to me, further, that such an extraordinary continental oscillation as that which brought about the change from the quiet Grand Gulf epoch to the stormy one of the Lafayette, would in most cases in itself constitute good cause for drawing a taxonomic line, as such lines are usually drawn. It can hardly be doubted that the change from the Grand Gulf to the Lafayette régime must have resulted in a material change in the character of the aqueous fauna, if any there was. We may therefore well question whether such events may not

as truly constitute the beginning of a new era—the Quaternary —as the incipient glaciation of the continent.

I have heretofore suggested that the extraordinary change of character from the Vicksburg to the Grand Gulf epoch—the substitution of brackish and fresh-water features for the exclusively marine—may have been caused by a diversion of the Gulf Stream to the outside of the Antilles, leaving the present Gulf as a receptacle for the continental waters, by the continued influx of which at least the north-shore deposits must have been sensibly freshened. However that may be, it is indisputable that from some cause there was a great increase of fresh water influx during the Grand Gulf epoch; and a still greater one during that of the Lafayette, completely excluding marine features from that formation, even where its beds actually project into the waters of the Gulf.

I, with Tuomey and others of the older geologists, have sought the origin of this increase of fresh-water influx in the melting of the continental glacier; and on the evidence before me of the actual translation of moraine material to low latitudes by such influx, and manifestly on a much steeper slope than now exists, or could exist during a period of submergence, I have attributed the Lafayette formation to a period of high elevation rather than one of depression; conceiving such elevation, greater in the northern latitudes, as a possible cause of glaciation.

As to the *extent* of such elevation, I have in former papers shown that, adding to the present maximum altitude of the loess summits in Louisiana (450 feet) the greatest depth at which gravel had then been found below sea level (in the bored wells of Calcasieu), viz: 450 feet, we obtain 900 feet as the minimum amount of the oscillation which has occurred since the gravel reached the Gulf shore. I am now enabled to increase this figure to 1200 feet, the gravel bed having been reached at the depth of 760 feet in the latest borings made at New Orleans. In this estimate no allowance is made for the degradation of the land surface that has occurred since the deposition of the loess.

But if the Lafayette gravels are found at the depth of 760 feet below sea level at New Orleans, it follows that at the time it was deposited, the land was *not* submerged, but stood higher at least to the extent of that same depth. The only escape from this conclusion is to prove that this gravel, together with that of the Calcasieu wells, and inferentially that of the Natchez profile, is not a part of the Lafayette at all but belongs to the Port Hudson epoch.

Admitting this for the sake of argument, where do we stand? We are then forced to conclude that at the beginning

of the Port Hudson epoch there existed the elevation of the continent which I have conjecturally assigned to the Lafayette time. According to Chamberlin and Salisbury, the loess, indissolubly connected with the Port Hudson, derives its materials from the continental moraine; and the Natchez profile, showing the moraine gravel lying at the base of the Port Hudson, conclusively settles this point. If then, as McGee contends, the Lafayette was formed during a period of submergence, it would be necessary to assume a reëlevation of the land prior to the beginning of the Port Hudson period, which, with the loess and overlying loams, manifestly represents a subsequent period of depression, coincident with the melting of the glaciers. The variations of materials within this Port-Hudson-Loess-Loam ("Columbia") series should, then, in some measure indicate the advances and recessions of the continental ice sheet.

The question is whether the "Orange Sand" of the Embayment does not represent the first period of recession and ice-melting, and the Port Hudson (or Columbia) series the second and final one. Under this point of view, instead of the double oscillation postulated by McGee, the land would simply have risen at the end of the Tertiary (Grand Gulf) period, assuming at the north a considerably greater altitude than at the south, as is postulated by the transportation of such large gravel to the margin of the Gulf. I gravely question that any such extreme elevation as has been suggested as necessary by Chamberlin (8,000 to 10,000 feet) would even now be required to re-glaciate the northern United States. Half of these figures would come nearer my estimate of the probable requirements, provided the rise extended into the arctic region, as is the case in Greenland.

It seems to me that, had the Tertiary climatic conditions (which in the Grand Gulf beds are made manifest by the extended prevalence of tree palms) continued during the Lafayette period, we could not help finding in its deposits the same evidences of a subtropic forest growth at some points. But no such evidences exist; all the fossil woods thus far identified and found within the Lafayette beds are derived from the underlying Tertiary, even though the process of silicification has probably occurred during Lafayette time, concurrently with the formation of the curious local masses of siliceous sandstone, which show plain intrinsic evidence of the intrusion of siliceous solutions into beds of loose white sand. In these at least, remnants of the peculiar plants of the period might be sought; but a few indistinct indications of what might be construed into roots or grass leaves are the only vestiges observed by any one. In the superficial paludal beds to which McGee

has called special attention and which in part at least undoubtedly fall within the Lafayette proper, such grass and sedge vegetation is all that is indicated. It argues, during the subaërial exposure admitted on all hands, a more rigorous climate than is consistent with our knowledge of even late Tertiary times; we are reminded of subarctic bogs, not of subtropic forests. It is in connection with such bog vegetation too, I think, that the process of ferrugination that is so conspicuous within the Lafayette, and has even given rise to iron ore deposits, is to be explained. It is obvious that the solutions which subsequently oxidized into limonite incrustations and ferruginous sandstone ledges, must have been of the same character as those now forming similar deposits in our northern latitudes; e. g. in Oregon and Washington, where under the influence of a cool, moist climate, limonite deposits and ferruginous sandstones are forming under our very eyes, from the seepage and drippings of the dense and ever moist covering of moss and grasses, percolating through more or less ferruginous surface beds and impregnating all pervious formations underlying, with what ultimately becomes a limonite cement for sands and sandy clays. A similar vegetative covering, with its concomitant reduction of the ferric hydrate resulting from the decomposition of hornblendic and other iron-bearing materials of the moraine sands, would naturally have covered the Lafayette surface when left free from overflow; and would explain the prominent ferrugination, as well as the fact that the minute grains of clay which we so frequently find intermixed with the quartz sand are so commonly, in contrast to the latter, decidedly angular, and have manifestly not undergone any sensible attrition. I conceive these clay-particles to be the result of kaolinization *in place*, under the influence of the carbonic acid solutions which evidently have been so very active within the entire formation as to leave little or nothing behind that is still subject to weathering, or carbonate solution.

I have in the foregoing discussion designedly confined myself to the ground with which I am familiar—The "Orange-Sand Delta" in and contiguous to the Mississippi Embayment; both because its phenomena *are* most familiar to me, and because I believe that, as previously stated, its development may have been largely independent of the events that happened beyond the Appalachian axis of upheaval and the Archæan highlands. How far such assumption may be compatible with the evidence in the possession of McGee, as regards the intervening ground in Georgia and farther east, the publications thus far made by him are insufficient to determine. But so far as they have been published, I cannot reconcile the lithological, stratigraphical and (negative) paleontological charac-

ters of his Appomattox with the idea of oceanic submergence, unless under conditions for which, in the actual state of our knowledge or conjecture regarding the climatic and surface conditions of the pre glacial epoch, we have there no adequate explanation. I therefore do not venture to suggest any for the Atlantic region, but do suggest for the critical region which has formed the subject of my special studies, such explanation as seems to me warranted by the regional facts, applicable to a very wide stretch of country distinctly correlated with the great axis of the Mississippi valley. The one prominent and indisputable fact, that after the Vicksburg period there has been a steady increase of fresh-water (or decrease of marine) conditions within the Gulf region, does not, so far as I am aware, apply to the Atlantic coast; and this distinctive and important feature requires special consideration and explanation. The latter may be found in the glacial phenomena, or as McGee has suggested to me, in the discharge of the great lakes of the continental interior toward the Mississippi valley, or in both combined. In either case these conditions have no analogue on the Atlantic slope south of the Hudson at least; and it would be precarious to attempt to gauge the two regions according to the same preconceived ideas. No one recognizes more than I do, the relative scantiness of our present information in the premises, particularly in view of the wide extent of country involved in any and every change in or near that common reference plane, the Gulf of Mexico. I feel confident that the practical recognition of the fundamental importance of this plane for the interpretation of the interior continental movements, and the consequent active investigation of its border lands as starting points, will quickly lead to the solution of many problems that have heretofore puzzled geological investigators at the heads of its drainage system.

ART. XLIX. — *On the Influence of Swamp Waters in the Formation of the Phosphate Nodules of South Carolina;* by CHAS. L. REESE, PH.D.

IN the introduction to Bulletin, No. 46, of the U. S. Geological Survey on "The Nature and Origin of Deposits of Phosphate of Lime," by R. A. F. Penrose, Jr., Prof. Shaler suggests that the South Carolina phosphates may have been formed by the action of swamp waters lying on beds of marl, and it was with this idea in view that I determined to look into the chemistry of the subject.

The South Carolina phosphates are nodular in form and found varying in size from that of a pea to nodular aggregates weighing ten pounds and more. They all have smooth and rounded surfaces as if water-worn and vary greatly in shape. The rock is found in beds varying from a few inches to one to two feet in thickness, underlying from three to ten and more feet of siliceous clay and overlying the calcareous marl of the region. It contains from 50 to 65 per cent of normal calcium phosphate; and the marl lying directly under it contains from 20 to 30 per cent of the same salt, which amount rapidly decreases at a depth of a few inches to 10 to 20 per cent and finally reaches the usual amount found in the marls—2 to 9 per cent.*

This concentration of phosphate in the marl directly underlying the rock clearly indicates a gradual segregation from the rock above.

The rock on examination with the eye, with and without the aid of the glass, is found to contain fossil shell forms and casts similar to those found in the underlying marl, but in a much better state of preservation and much harder in the former than the latter.

I have found, in many instances, in the cavities which have been left by shells between the outer and inner casting, a brownish white, very finely divided powder, which gave on analysis 84·65 per cent calcium phosphate [$Ca_3(PO_4)_2$], a small quantity of silica, of fluorine, organic matter and the rest calcium carbonate. This clearly shows the direct replacement of the carbonate of the shell by phosphate.

From the similarity in structure of the phosphates and the marls, and their occurrence, it is clearly seen that the former are the phosphatized product of the latter; and the object of my work has been to see how far swamp water could have aided in bringing about this result.

There has been considerable work done on the action of the so-called humus acids (humus, crenic and apocrenic acid, etc.) on the soil† and also on phosphates‡ in the soil, and it was my intention to study the action of these acids on the normal phosphate of calcium both alone and in the presence of calcium carbonate; but owing to their uncertainty of composition, the extreme difficulty of obtaining them in a pure condition, and particularly their liability to undergo change in attempts to isolate them, I decided to study their action in their native condition, and under circumstances as nearly as possible like those under which they act in nature.

* C. U. Shepard.

† A. A. Julien. Am. Association for Advancement of Science, Proceedings, 1889.

‡ J. M. Bemmellen, Landwirtschaftliche Versuch-Station, 35, 36.

I obtained a series of specimens of water from both fresh and salt water swamps, as well as of the deposits from the bottom of the same, from the neighborhood of Georgetown, South Carolina, but after a preliminary and unsuccessful test for phosphate with ammonium molybdate with both of them, I decided for a number of reasons, only to use the specimens from the fresh water swamp. The salt waters contain very little organic matter, and are constantly changing, and could consequently have little effect; whereas the fresh swamp waters are dark in color, and contain a large quantity of organic matter, and are at the same time more or less stagnant, not being affected by the tides at all. The material from the bottom of salt swamps consists mainly of the roots of marsh grass, whereas that from fresh swamps is composed of an accumulation of decaying leaves, roots, etc. Finally I have been led to believe that fresh swamps have been influential in the formation of phosphate nodules from the fact that cypress stumps are frequently found in the phosphate beds, and occasionally an amber-like substance.*

On getting no appreciable test for phosphoric acid in the swamp waters, I allowed specimens of fresh swamp waters to stand for two weeks mixed with precipitated and carefully purified calcium phosphate, filtered, evaporated to dryness ignited, and tested for phosphoric acid with negative results in each case.

I next mixed the material taken from the bottom of fresh water swamps (composed of cypress and black gum leaves and roots, sand, etc.), with swamp water and normal calcium phosphate, and allowed the mixture to stand one day, filtered, and filtrate gave slight test for phosphoric acid. On evaporating to dryness, igniting, and redissolving in nitric acid, it gave a heavy yellow precipitate with ammonium molybdate, showing that some of the phosphate had gone into solution.

In subsequent experiments, by allowing the mixture to stand for a longer time, I got heavy precipitates of phosphomolybdate without evaporating.

Further experiments, in which the floats of the natural phosphate rock were used instead of the precipitated phosphate, gave similar results although not so marked, as should be expected, owing to the presence of some calcium carbonate which would have a tendency to cause the phosphate to be reprecipitated, particularly after the action of the humus materials should be completed, as is shown in the results of later experiments. The floats are also less finely divided, and hence we could not expect the phosphate in them to be so rapidly dissolved.

* This substance will be described in another paper.

These experiments having demonstrated the solubility of the normal phosphate in water in the presence of decaying vegetable matter, such conditions as are found in the bottom of swamps and at the same time in soils containing vegetable mould, the question presents itself as to how the solution is brought about, that is whether it is owing to the conversion of the tri- into the mono-calcium phosphate by the acid action of the mixture (humus acids) or to the formation of certain absorption compounds with the so-called humus acids as described by Bemmellen,* or to both. I think it likely that both processes enter into the reaction, and it is intended to carry out further investigation in the direction of solving this problem.

On neutralizing the solution with ammonia, the phosphate was partially precipitated, while neutralization with calcium hydroxide caused a complete precipitation.

To determine whether water then charged with phosphate would give it up in coming in contact with marl, I allowed specimen to stand in vessels over pure calcium carbonate in some instances, and marl in others; and in each case all trace of phosphoric acid was removed in the course of twenty-four to forty-eight hours.

It is highly probable that carbonic acid plays an important part in the formation of the phosphate nodules, so that it is important to consider its action in this connection.

Carbon dioxide passed into water containing normal calcium phosphate dissolves it under the formation of mono-calcium phosphate and acid calcium carbonate, so that the solution contains both of these substances.

This solution remains unaltered on standing, but if it be boiled or allowed to stand over normal calcium carbonate or marl, all of the phosphate will be precipitated, as was demonstrated by a number of experiments, just as in the case of solution of phosphate by means of swamp water mixture. This experiment shows that phosphates may be transported in hard waters, but on standing on calcareous beds would tend to be given up.

From these experiments it certainly seems probable that both carbonic acid and the humus substances in fresh water swamps play an important part both in the accumulation and the concentration of calcium phosphate, and the formation of nodules in this way. The marls in the first place contain a small percentage of phosphate, which percentage would be gradually increased as the carbonate is gradually removed.

Calcium phosphate, held in solution from whatever source as the diacid salt, or in combination with the so-called humus

* Landswirtschaftliche Versuchs-Stationen, xxxv, p. 130.

acids as absorption compounds, on coming in contact with the carbonate of the marl, which forms the bottom of the swamps, is deposited either as the mon-acid or normal salt (if the former it changes into the latter in the course of time) and carbon dioxide is liberated. This carbon monoxide in its turn dissolves some of the carbonate, thus bringing about a concentration and consequent tendency toward nodulation as will be seen from the reaction; one molecule of the phosphate would remain and four molecules of the carbonate would be removed.

$$2\ CaCO_3 + H_4Ca(PO_4)_2 = Ca_3(PO_4)_2 + 2H_2O + 2CO_2$$
$$2\ CaCO_3 + 2CO_2 + 2H_2O = 2H_2Ca(CO_3)_2$$

The humus substances also give off carbon dioxide on decomposition and consequently we have a further cause for concentration from this source.

There can be no doubt, from the similarity in structure, that the phosphatic nodules are phosphatized marls. And from their occurrence in beds in a country that has in recent geological history been covered from time to time with swamps, some of which at present underlie a bed of argillaceous sand covered by salt marsh, taken together with the above observations and experiments, it certainly seems probable that swamp waters have brought about this change through the agency of carbonic acid and the humus substances contained in them.

The question as to the source of these large deposits of phosphates is of course a very difficult one to answer. There are many fossil remains of animals found associated with the rock but their numbers do not seem to be sufficient to account for the large quantity of the phosphate found. Again these fossils (mainly sharks' teeth and bones) seem to be of a later date than the nodules, as was suggested by Mr. Penrose, owing to the fact that they are not embedded in the nodules but are simply found loosely mixed in with them. Some of the phosphate is that which was originally in the marls, and I might suggest as other sources, that brought down in solution by drainage, and a small quantity contributed by the potassium phosphate from the decomposition of vegetable remains, particularly such accumulation in swamps.

"The Citadel," Charleston, S. C., Jan. 20th, 1892.

ART. L.—*Plattnerite, and its Occurrence near Mullan, Idaho;* by WILLIAM S. YEATES, *with Crystallographic Notes;* by EDWARD F. AYRES.

[Read before the Chemical section of the American Association for the Advancement of Science at the meeting in August, 1891, at Washington, D. C., and published by permission of the Assistant Secretary of the Smithsonian Institution.]

UNDER the name, Schwerbleierz, in the year 1837, lead dioxide as a mineral species was described by Breithaupt.* A quantitative determination of the lead by Plattner was given. As to its occurrence, Breithaupt† says, that the only piece of the mineral obtained by him was a large botryoidal mass formed of concentric layers, almost entirely covered by cerussite, pyromorphite and leadhillite. Also, that he did not know the place of its occurrence; but, as the last-named mineral was then known to occur only at Leadhills, Scotland, he concluded, that the "Schwerbleierz" was probably found at that locality. The mineral is described as having a metallic-adamantine luster, becoming dull by tarnish; in color, iron-black, with brown streak; opaque; crystallized and massive, the crystals, rhombohedral, in hexagonal prisms with the combination, P, ∞P, OP; indistinctly cleavable; fracture, uneven; brittle; specific gravity, 9·392 and 9·448, the result of two determinations. Some years after the mineral was described by Breithaupt, Haidinger‡ gave it the name of plattnerite, and, a little later, Hausmann§ called it braunbleioxyd. In 1858, Greg and Lettsom‖ used the name plattnerite, in describing the species in their mineralogy, and added this note:—"The authors can learn nothing more about this species, and consider it a doubtful one. The specific gravity seems too high to be correct, since it is double that of minium, and even more than that of galena. The crystals, described as being hexagonal prisms, may possibly have been pseudomorphous of pyromorphite." In Dana's Mineralogy,¶ under plattnerite, the following comment is made:—"A doubtful species. The specific gravity given is as high as that of the protoxyd of lead."

In a paper read before the Mineralogical Society of London, June 22nd, 1886, Prof. Edward Kinch** described a well authenticated specimen of plattnerite from Leadhills, Scotland, giving

* J. pr. Ch. (1837), x, p. 508. † Loc. cit.
‡ Handb. der Best. Minn. (1845), p. 504.
§ Handb. der Min. (1847), p. 202.
‖ Manual of Min. (1858), p. 389.
¶ A System of Mineralogy, by James D. Dana (1868), p. 167.
** Min. Mag. London, vol. vii, p. 63 (1886).

the hardness at about 5, and the specific gravity at 8·54; and its composition, PbO, 92·66; O in excess of PbO, 6·20 (by direct determination.) In another paper before the same society on March 12th, 1889, Prof. Heddle* describes a specimen of plattnerite from Belton Grain Vein, Wanlockhead, Scotland, and a specimen from Leadhills, both of which had been in his possession some years. The specific gravity of the first is given at 8·8 to 8·96; and that of the latter, at 9·27. In May, 1889, the writer of this paper identified as plattnerite a specimen, which had been sent to the National Museum, by Mr. Waldo J. Clark, of Mullan, Idaho. A brief preliminary note, announcing the occurrence, was sent to this Journal. A reference to this note appeared in the July number,† as did, also, a note on the same subject from Prof. H. A. Wheeler, of St. Louis, giving a brief description and an analysis. In the August number of the Journal, Messrs. J. D. and E. N. Hawkins‡ described a specimen of the plattnerite, which had fallen into their hands, giving two analyses.

In the meantime, the writer had secured a considerable quantity of the material, with the view to describing, more in detail, its occurrence in Idaho; and his investigations had developed facts not referred to by Mr. Wheeler or the Messrs. Hawkins.

In a letter from Mr. Clark, who had kindly furnished the writer with the material, he says that he discovered the plattnerite in a tunnel in the "You Like" lode, Hunter mining district, three miles northwest of Mullan, Idaho, on a spur of the Cœur d'Alene mountains, at a distance of 70 feet from the surface; and that it occurred in "round knobs or bunches" in a continuous line, touching each other "for a distance of 20 feet, when the iron§ appeared to crowd it nearly out for 10 feet, then considerable of it for 10 to 15 feet farther, when it disappeared," and no more was found as far as the tunnel was run, a distance of 40 feet.

The intimate associates of the plattnerite are limonite and white pyromorphite, the former occurring in botryoidal masses and as a brown ocher; the latter, in crystals, rarely in veins, scattered through some of the nodules. The plattnerite occurs in botryoidal nodules embedded in a mixed ocher of limonite and plattnerite, which contains, scattered through it, loose crystals of pyromorphite, when the nodule, within, contains them. When this ocher is cleaned off, and the nodule is broken open, the fresh surface exhibits a small conchoidal fracture and a bright metallic-adamantine luster, which tarnishes and becomes

* Min. Mag., London, vol. viii, p. 203 (1889).
† This Journal, xxxviii, July, 1889, p. 79.
‡ This Journal, xxxviii, Aug. 1889, p. 165. § Limonite.

dull on exposure to the atmosphere for a few weeks. While the outside of the nodule is a reddish-brown, the fresh fracture reveals an iron-black color and a very compact cryptocrystalline structure. The streak is chestnut-brown; hardness, 5·5; specific gravity, 8·56;* opaque; brittle. Before the blowpipe, on charcoal, in the oxidizing flame, it decrepitates and fuses at 1, with boiling and spirting, yielding a globule of lead, which, on further heating, coats the coal yellow. It is easily soluble in cold, dilute HCl, giving off chlorine.

An analysis of an apparently pure fragment gave the writer the following results:

Lead	83·20
Silver†	trace
Copper	0·14
(Fe, Al)	1·20
Oxygen	12·93
Insol. residue	0·82
Total	98·29

Neglecting impurities, and calculating to 100, we have

Lead	86·55
Oxygen	13·45
Total	100·00

Calcium and magnesium, in appreciable quantities, were found both in the qualitative and quantitative analyses; but they were not estimated. The oxygen was determined directly as H_2O, by passing H over the powdered mineral, heated in a combustion tube at low red heat, the H_2O being caught in a series of calcium chloride tubes.

The specific gravities, as given by Breithaupt‡ and Wheeler,§ for the natural lead di-oxide, are higher than is required by its constitution; and, until the investigation by Kinch, the high specific gravity was cited as sufficient ground for doubting the authenticity of the species. That given by the Messrs. Hawkins‖ was as much too low. This, however, may be accounted for in the fact that their analyses show nearly 10 per cent. of impurities in the material analyzed

* The specific gravity was carefully determined in a pycnometer with attached thermometer, the mineral (3·1815 grams) being reduced to minute fragments, and the air being pumped from it. Determinations of the specific gravity, made, with the Jolly balance, on two other fragments, gave 8·35 and 8·86, the latter being on a very small fragment.

† 4·6463 grams of plattnerite yielded a silver button weighing 0·0022 grms.

‡ 9·392 and 9·448. § 9·411.

‖ 7·25 ("the mean of three close determinations").

by them. The specific gravity of artificial lead dioxide is variously stated to be 8·902 (Herapath),* 8·933 (Karsten),† 8·756, 8·897 (Playfair and Joule),‡ and 9·045 (Wernicke).§

The sizes of the nodules vary from $2'' \times 1'' \times \frac{1}{2}''$ to $8'' \times 6\frac{1}{4}'' \times 4\frac{1}{4}''$, one of the largest masses weighing 15 lbs. 4 oz. Implanted on many of them are crystals of the white pyromorphite; and, as has been mentioned above, these nodules, when broken open, are speckled with this mineral. Some of these crystals are brown, being coated by a film of plattnerite; and, until this film was cut through and the true nature of the crystals determined, they were thought to be plattnerite crystals. As the plattnerite was originally described‖ as being rhombohedral, occurring in hexagonal crystals, and as Greg and Lettsom¶ had suggested, that it might possibly be pseudomorphous after pyromorphite, thin sections were made, and, at the writer's request, these were kindly studied under the microscope by Mr. Geo. P. Merrill,** who reported, that he could find no evidence that any alteration of the pyromorphite into plattnerite had taken place. One large specimen of plattnerite, when broken open, showed sharp angular fragments of milk-white quartz, which formed a breccia with the plattnerite as the cement.

In breaking open specimens to obtain the fresh fracture, the writer observed, that, here and there, would be one, which was distinctly fibrous, in part, the fibers running from the dense, black, cryptocrystalline material to irregular, small cavities, which were, more or less, filled with a bright yellow-ocher. These fibers seemed to terminate in minute jet-black crystals, penetrating slightly into the ocher. These were so imperfect, however, that the form could not be made out, even with a strong lens. The fibers, when examined, were found to be plattnerite. A few drusy surfaces, which had been the sides of small fissures, were observed; and these, on examination under the microscope, the writer found to be made up of slender crystals, to all appearances tetragonal, and strikingly like certain cassiterite crystals from the Dolcoath mine in Cornwall, except that they were opaque. Examination proved, that these crystals were plattnerite. At the writer's request, Mr. Edward F. Ayres of the U. S. Patent Office very kindly undertook the delicate crystallographic work required. His description is hereto appended.

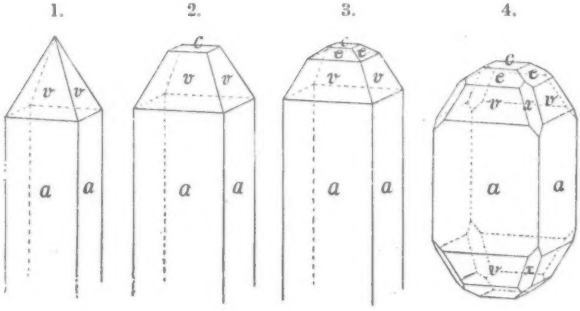
* Phil. Mag., London, etc., lxiv, p. 321.
† Schweigg. Jour., lxv, p. 394.
‡ Mem Ch. Soc., iii, p. 84.
§ Jour. Ch. Soc. (II), ix, p 306.
‖ Loc cit. ¶ Loc. cit.
** Curator, Dept. of Geology, U. S. National Museum.

In conclusion the writer desires to tender his thanks to Mr. Clark, who so generously furnished the material for study and the data for the description of its occurrence.

Crystallographic Notes.

From the specimens of plattnerite submitted to the writer by Mr. W. S. Yeates the following results were obtained. The crystals of plattnerite (PbO_2), which look very much like cassiterite, are very minute, varying from $\frac{1}{50}$ to $\frac{1}{1000}$ of an inch in length, and are found filling crevices in the massive plattnerite. Moreover, they are tetragonal and isomorphous with rutile (TiO_2), cassiterite (SnO_2), and polianite (MnO_2), all minerals which have a similar chemical composition.

The color is black, and where the planes are smooth, the crystals are very bright, having a nearly adamantine luster. No cleavage could be distinguished and the crystals are very brittle.



The prevailing form is that shown in figures 1 and 2, the basal plane being very common; many of the smaller crystals, however, have simply the steep pyramid v (301) terminating the prisms as seen in fig. 1. The crystal, which gave much the best results, was about the $\frac{1}{150}$ of an inch long and of the form and about the proportions shown in fig. 3. The forms observed, referred to the common axial ratio of this group of dioxides, are:

a (100, ∞-∞)	e (101, 1-∞)	x (332, $\frac{3}{2}$).
c (001, O)	v (301, 3-∞)	

The plane x, (332), bevelling the edge between the pyramids v, (301) was observed in a few instances.

The prismatic faces are badly rounded and considerably striated, and though bright, could not be depended on for any correct measurements since their reflection extended over a

space of two degrees. The pyramid v (301) was very bright and quite large and well defined; and the pyramid e (101) was also bright but very small. The basal planes were rounded and apparently pitted and rough.

On account of the very minute character of the pyramidal planes, correct measurements were difficult to make, the use of the signal in a reflecting goniometer being entirely out of the question, on account of the small amount of light and reflection in the goniometer being all that could be employed. The manipulations necessary to place the crystal in position were also very delicate. The angle between 301 and $\bar{3}01$ gave the best definition, and the mean of many measurements, 127° 32′, gives the axial ratio

$$a : c = 1 : 0{\cdot}67643$$

The following are calculated and measured angles for the forms 301 and 101.

	Calculated.	Measured.
301 ∧ $\bar{3}01$	*127° 32′	127° 32′
301 ∧ 100	26 14	24 30
301 ∧ 101	29 41 28″	28 1
101 ∧ 100	55 55 28″	54 39 30″
101 ∧ 001	34 4 32″	35 20 30

Rutile gives the axial ratio $a : c = 1 : 064415$, and though the habit of these crystals differs from that of the other members of the group, in that the diametral prism is alone present, it is to be noted that the pyramid v (301) here prominent is a twinning plane with rutile.

U. S. National Museum, Feb. 29th, 1892.

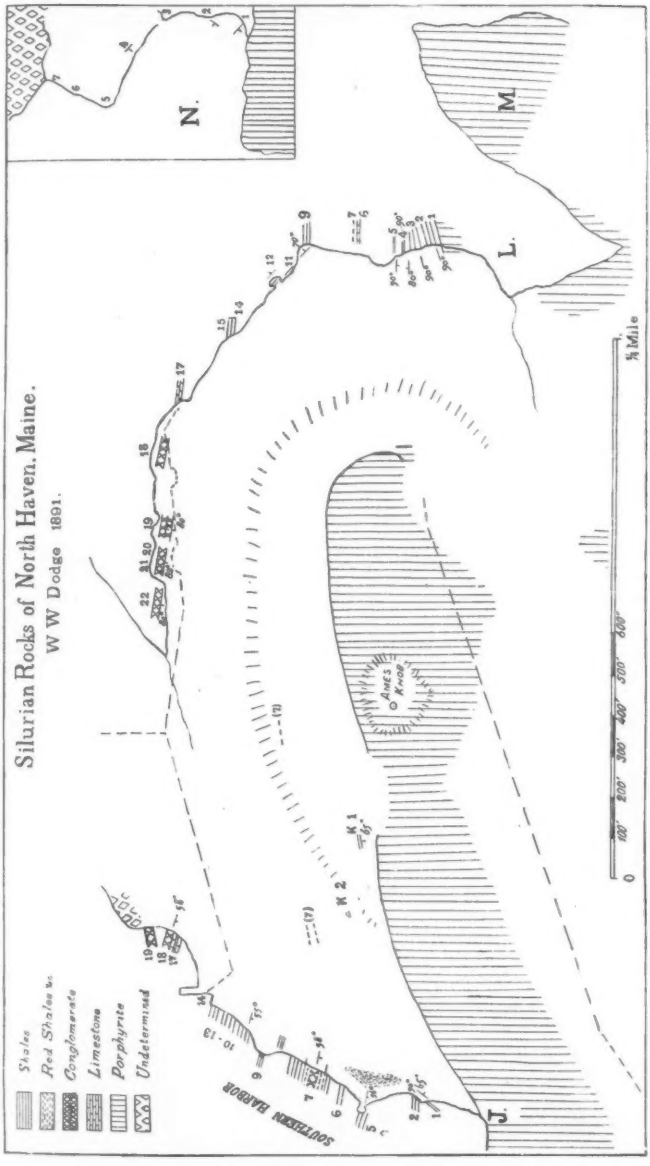
ART. LI.—*On the occurrence of Upper Silurian Strata near Penobscot Bay, Maine;* by WILLIAM W. DODGE and CHARLES E. BEECHER. (With map.)

I.

ON the island of North Haven in Penobscot Bay, there is an extensive exposure of abundantly fossiliferous rocks of Silurian age.

The region where they are found is included in United States Coast Survey chart 311a (1:20,000), Fox Islands Thoroughfare, also in 310 (1:40,000), West Penobscot Bay. The sketch map, herewith, indicates the points at which the fossils specified by Mr. Beecher in the second part of this paper were obtained, giving also strike, dip, and character of beds.

For five-eighths of a mile northward from Fox Islands Thoroughfare (the strait which separates North Haven from


Silurian Rocks of North Haven, Maine.
W W Dodge 1891.
Shales
Red Shales &c.
Conglomerate
Limestone
Porphyrite
Undetermined
SOUTHERN HARBOR
AMES KNOB
N.
M.
L.
J.
K 1
K 2
½ Mile

Vinal Haven), the greater part of the rock between Southern Harbor and Waterman's Cove is eruptive, probably porphyrite. In many places it holds innumerable fragments of rock somewhat similar to itself, of earlier consolidation. The highest of the several hills formed by the eruptive rock (145 feet above tide), three quarters of a mile northwest of the village of North Haven, is known as Ames's Knob.

The fossiliferous strata lie immediately north of the area of eruptive rock, occupying lower ground. They run about east and west, with prevailing southerly dip, and have a thickness of about six hundred feet. Their preservation at an accessible level is due to the protection against glacial erosion afforded by the more resistant eruptive rock.

Fossils have been found at more than twenty different points in the three quarters of a mile between the shore of Southern Harbor and the road from North Haven village to Pulpit (or Northern) Harbor. Between the road and Waterman's Cove the beds are mostly covered; the outcrops have not been examined for fossils. Two miles farther east, dark bluish-gray, brown-weathering limestone, like one member of the North Haven series (J 17, L 17, O), and overlying quartzite cross the western end of Stimpson's Island obliquely from northwest to southeast, in a narrow belt between eruptive rocks. The limestone there has yielded only an indeterminable brachiopod and a crinoid disk.

In recording the localities of the fossils collected, outcrops along the shore of Southern Harbor are designated by the letter "J"; those inland along the north side of Ames's Knob are marked "K"; those along the west shore of the shallow bay that opens into Southern Harbor northeast of Ames's Knob are lettered "L"; the point that projects into the head of that bay is occupied by the eruptive rock, but is called "M"; the eastern shore of the same bay is indicated by "N"; the outcrop at the west side of the Pulpit Harbor road, near the edge of the woods, by "O." The numbers run from south to north; that is, from higher to lower beds.

The section on North Haven, beginning with the lowest beds of the group, is approximately as follows:

	Feet.
Conglomerate containing pebbles of quartz, schist, etc., J 19, concealed or absent elsewhere	12
Concealed (J and L), measured on J	59
Conglomerate with pebbles of quartz and of schist, sandstone, a few layers of shale, L 22–19, dip S. 5° W., 80°, the conglomerate fossiliferous in a few places. Coarse calcareous sandstone (fossiliferous) with alternating finer calcareous beds, J 18, dip S. 19° W., 58°	16

	Feet.
Brown- or ochre-weathering, dark bluish-gray, impure limestone, J 17, L 17, probably O. Fossils distinguishable only on weathered surfaces	21
Concealed	75
Light colored porphyry, J 14, L 14	3
Dark bluish-gray indurated shale (J and L 13–8), slightly calcareous in places, sometimes with calcareous nodules, greenish-gray in upper portion. Many fossils at L 12 and some at L 9. The plane in which fossils lie at L 12 shows the strike at that point to be N. 55° W., dip N. 35° E., 70°. Exposure not continuous either on J or L. In detail, on J,—shale, dipping at top S. 8° W., 55°, 115 feet; concealed 22′; shale 20′; concealed 15′; shale 8′; concealed 20′; greenish-gray shale (J 8) 45′	203
Red shale (holding nodules of white limestone at one point), red and white sandstone and conglomerate, J 7, dip S. 9° W., 60°; L 7, low tide exposure only	42
Various, usually hard, argillaceous, occasionally calcareous, beds, with subordinate strata of limestone, frequently cross-bedded, with varying strike and dip (J 1, S. 35° E., 65°; J 2, vertical; J 5, S. 10° W., 56°; K 1, S. 14° E., 65°; L 1, N. 25° W., 80°; L 2, vertical; L 3, N. 20° W., 68°–85°; L 5, S. 70°); fossiliferous at J 6, 5, 2 (the first two respectively 42 and 85 feet above the red beds); K 1 (about 125 ft. above the red beds), K 2; L 5, 4, 2, 1; thickness about	175
Total	606

This is obviously a shore and shallow water deposit.

The band of porphyry low in the section, J 14, L 14, seems to follow the bedding, but at L 14 is seen to extend northward and cross the underlying strata.

The eruptive rock south of the fossiliferous beds cuts across them (N 1), and at one place (M) was seen surrounding a fossiliferous fragment of one of the highest beds in the series. Near the contact, the stratified rocks are disturbed and sometimes violently twisted and broken (N 2).

Within the mass of the eruptive rock are included some strata which appear to be higher in position than the fossiliferous rocks above described. A long band of coarse conglomerate extends from near the peak of Ames's Knob to the shore of Southern Harbor just north of a stone wall which is indicated on the Coast Survey charts. A sandstone layer in this conglomerate gave the strike N. 55° E. Still farther south, half way from the wall to the shore of the Thoroughfare, and 120 yards east from the bay east of Turnip Island, red shales and fine sandstones (strike N. 68° W., dip S. 22° W., 60°) are surrounded by the eruptive rock, which is seen crossing the beds.

Along the north shore of the Thoroughfare, east of the village, are red shales that closely resemble those north of Ames's Knob, J 7. Here also the dip is southward. They overlie a mass of diabase, which is vesicular in its upper (southern) portion. A layer of light colored porphyry lies among the shales and extends westward along the shore between the wharves at the village. Farther west, near the ferry landing, are fragmental rocks with an ash-like cement, which must overlie the red shales. In this vicinity are dykes of diabase and of light colored porphyry showing flow structure parallel to its walls.

The northern part of Vinal Haven, excepting Calderwood's Neck, is made up largely of felsophyre (laminated, sometimes spherulitic) and felsophyre-breccia, with porphyrite and diabase. The southern part, including the greater portion of the area of the island, is mainly occupied by granite. Along the northwestern side of Seal Cove, which opens into the Thoroughfare, is a limited region of altered schists, into which are intruded dykes from the granite near the head of the Cove. The schists strike N. 20°–40° E., and dip northwestward, 40°–55°.

The presence at North Haven of a familiar species of Monograptus gives an interesting item of information in regard to the geographical distribution of Upper Silurian graptolites in America, of which but little is yet known. Graptolites have been reported as occurring at a few Upper Silurian localities in New Brunswick, Nova Scotia and Newfoundland. Repts. Canada Geol. Surv., 1885, pp. 14, 15 G; 1874–5, p. 10, 1885, p. 52 E; 1886, pp. 43, 46 P; Geology of Newfoundland (1871 Rept.), p. 31. They were mentioned as occurring at Anticosti at a somewhat high level in the (Middle Silurian) Anticosti Group, Rept., 1853–7, p. 253, 1863, p. 302, but were not included by Billings in his first published list, or in his catalogue of 1866. W. W. D.

II.

The paleontological evidence furnished by the specimens from North Haven apparently does not admit of a distinct subdivision of the rock series into recognized periods. A large proportion of the species clearly points to a correlation with the Niagara of New York, and to this period they are here referred. The presence of quite a number of characteristic Clinton species is a disturbing element in any attempt to draw exact parallelisms with the New York subdivisions of the Upper Silurian. From present data, however, it seems justifiable to consider the fossiliferous rocks at North Haven as representing a faunal equivalent to the Clinton and Niagara,

with a decidedly strong Niagara facies. Therefore, the broader term Niagara will more correctly express the chronological relations of these strata.

The Clinton species are mostly confined to the lower half of the series. This is of considerable significance, but, at the same time, nearly all the typical Niagara forms are associated with them in abundance. Another fact to be noted is the conspicuous absence of some species from the entire series; as, *Caryocrinus ornatus*, *Spirifer niagarensis*, *Rhynchotreta cuneata*, and *Pentamerus oblongus*. Similar discrepancies occur in the Niagara fauna at Waldron, Indiana, and elsewhere, and merely serve to give distinctive features to such faunas.

List of fossils with their location in the section and on the map.

Monograptus clintonensis *Hall*, L 12.
Cœnostroma sp., L 19.
Streptelasma calyculum *Hall*, L 12. J 18, L 19.
Chonophyllum niagarense *Hall*, O 18.
Favosites venustus *Hall*, L 19.
Favosites niagarensis *Hall*, L 19.
Favosites favosus *Hall*, J 18.
Cladopora sp., O 18.
Cœnites ramulosus *Hall*, O 18.
Monticulipora sp., J 5.
Halysites catenulatus *Linné*, L 19.
Heliolites spinoporus *Hall*, L 19.
Crinoid fragments, J 1, L 1, N 1, L 12.
Cornulites sp., N 2.
Tentaculites sp., N 2.
Encrinurus punctatus *Wahl.*, L 9, L 12, O 18.
Calymene niagarensis *Hall*, K 1.
Dalmanites limulurus *Green*, K 1, J 6, L 9, L 12.
Ceraurus niagarensis *Hall*, K 1.
Illænus ioxus *Hall*, L 9, L 12.
Proëtus Stokesi *Hall*, K 2.
Beyrichia. 2 species, L 4, J 6.
Leperditia sp., K 2, L 4.
Fenestella sp., K 7. (In limestone nodule.)
Stictopora sp, K 2.
Lingula lamellosa *Hall*, L 12.
Schizocrania sp., L 4.
Orthis elegantula *Dal.*, K 1, N 1, K 2, N 2?, J 2, N 3, N 5, L 5, J 6, L 12.
Orthis hybrida *Sow.*, L 2.
Orthis, 2 species, L 12, O 18.
Leptæna transversalis *Wahl.*, L 12, O 18.
Leptæna (cf.) sericea *Sow.*, K 1, K 2, N 2, J 2, J 6.
Strophomena rhomboidalis *Wilc.*, L 12.
Stropheodonta profunda *Hall*, N 5.
Streptorhynchus subplanum *Con.*, K 1.
Chonetes cornutus *Hall*, L 4.
Pentamerus occidentalis *Hall*, L 19.
Meristina nitida *Hall*, K 2?, J 5, L 9?
Meristina sp., J 5.
Nucleospira pisum *Hall*, O 18.
Cœlospira disparilis *Hall*, L 9.
Spirifer crispus *His.*, K 1, N 1, J 2, K 2, N 2, L 5, N 5, J 6, O 18.
Spirifer sulcatus *His.*, J 5.
Spirifer radiatus *Sow.*, L 12.
Cyrtina pyramidalis *Hall*, J 6.
Atrypa reticularis *Linné*, K 2, N 5, J 5, L 5, L 9, L 12.
Atrypa nodostriata *Hall*, O 18.
Rhynchonella neglecta *Hall*, K 1, N 1, J 2, N 2, N 5.
Rhynchonella obtusiplicata *Hall*, K 1.
Rhynchonella sp., K 2, J 2.
Rhynchonella (Wilsonia) sp., K 1, N 2.
Nucula sp., K 1.
Tellinomya sp., N 2.
Avicula demissa *Con*, K 1.
? Avicula subplana *Hall*, L 12.
Avicula sp, L 5.
Cypricardinia sp., O 18.
Platyostoma niagarense *Hall*, L 12.
Loxonema sp., K 1, L 12.
Pleurotomaria sp., K 1, L 4, L 12.
Bellerophon sp., K 1, L 12.
Cyrtolites sp., L 12.
Murchisonia sp., L 12.
Hyolithes sp., N 4.
Orthoceras annulatum *Sow.*, K 1, L 9, L 12.
Orthoceras subcancellatum *Hall*, L 12.
Orthoceras virgulatum *Hall*, L 9, L 12.
Orthoceras (annulated), 2 species, L. 12.
Gomphoceras sp., L 12.
Cytoceras subcancellatum *Hall*, L 12.

Summary.

Hydrozoa,	2 species.	Brachiopoda,	27 species.
Actinozoa,	10 "	Pelecypoda,	6 "
Annelida,	2 "	Gastropoda,	6 "
Trilobita,	6 "	Pteropoda,	1 "
Ostracoda,	3 "	Cephalopoda,	7 "
Bryozoa,	2 "	Total,	72 "

Nearly all the corals are confined to the lower beds, J 18, L 19, and O 18; the first two are a conglomerate of coral fragments with pebbles of quartz and hydromica schist, while the latter is a limestone. The greatest number of species (24) is found near the middle of the series (L 12) in a slightly indurated shale. The fauna was evidently a rich one, and several of the unidentified species are probably new to science. Many of them show distinctive characters, but the majority are too fragmentary and poorly preserved for accurate description or determination. C. E. B.

ART. LII.—*Zinc-bearing Spring Waters from Missouri;* by W. F. HILLEBRAND.

ZINC salts have been observed in the waters from La Malou in the south of France, according to Doelter,* and in those of certain hot springs of New Zealand,† perhaps also in those of other localities, but I have as yet been unable to find any data bearing upon their contents in such salts. Durand-Fardel's Dictionnaire des Eaux Minerales, 1860, fails to include zinc as a constituent of the waters of La Malou which had been analyzed up to that time. It is therefore improbable that this element is present there in any considerable quantity.

The spring waters herein described are, it is thought, unique, in that their chief salt constituent is zinc sulphate. The following information in regard to the location and surroundings of the springs from which they flow has been obtained from Mr. W. P. Jenney of the U. S. Geological Survey, who was led to suspect a peculiarity of composition from the strong metallic astringent taste left in the mouth after swallowing, and by the slimy white precipitate which covers the walls of the springs and all vegetable matter falling into the water about them.

On the road from Joplin to Seneca, in Newton County, southwestern Missouri, about a quarter of a mile north of

* Allgemeine chemische Mineralogie, p. 233.
† Trans. and Proc. New Zeal. Institute, 1870, vol. iii.

Shoal Creek and four and a half miles southwest of Joplin is a low bluff, perhaps 18 feet high, formed by a portion of the Burlington Chert Beds. At the base of this bluff, in a shallow depression, is a series of springs extending for a distance of perhaps 150 feet and emptying their waters into the above mentioned depression, wherein a sluggish current is produced and a deposition of a slimy white precipitate takes place. They vary in size, discharging from one-half to three gallons of water per minute, and about 30 gallons, or 150 to 160 liters, in the aggregate. So far as can be judged by the taste they vary also in composition, some waters being much stronger than others.

The two samples analyzed were taken by Mr. James A. Reeves, of Joplin, from springs about 90 feet apart, designated as the East Spring and the West Spring, which were not only the most powerful, but which also, judged by the taste, furnished the strongest water. The composition as given below is that of the water after having stood in sealed bottles for two or three weeks and having been then separated by filtration from a whitish flocculent deposit which was probably formed after collection of the samples, in which case the reported composition does not exactly represent that of the water as it issued from the spring. As received the waters were clear and limpid above the sediment, they were neutral to litmus paper, and their density differed but little from that of pure water, that of No. I being 1·0006 at 20½° C. The samples were too small and time was too valuable to admit of exhaustive examination or of duplication of determinations. The analyses are as follows:

	I. East Spring. Parts in 1,000,000.	II. West Spring. Parts in 1,000,000.		I. East Spring. Parts in 1,000,000.	I. East Spring. Percentage Composition.	II. West Spring. Parts in 1,000,000.	II. West Spring. Percentage Composition
Pb	trace	undet.	$PbSO_4$	trace	trace	undet.	undet.
Cu	·2	"	$CuSO_4$	·5	·09	"	"
Cd	·5	?	$CdSO_4$	·9	·17	?	?
Zn	120·5	132·4	$ZnSO_4$	297·7	55·14	327·0	57·14
Fe	·6	·6	$FeSO_4$	1·6	·30	1·6	·28
Mn	2·3	2·4	$MnSO_4$	6·3	1·17	6·6	1·15
Al	·4	·5	$Al_2(SO_4)_3$	2·5	·46	3·2	·56
Ca	61·1	63·1	$CaSO_4$	109·9	20·34	85·8	14·99
Mg	3·8	4·2	$MgSO_4$	19·0	3·52	21·0	3·67
K	2·5	2·5	K_2SO_4	5·6	1·04	5·6	·98
Na	3·6	3·9	Na_2SO_4	5·9	1·09	6·8	1·19
Cl	2·6	2·6	NaCl	4·3	·80	4·3	·75
SO_4	284·9	287·6	$CaCO_3$	72·0	13·34	94·7	16·55
CO_2	43·2*	56·8*	SiO_2	13·7	2·54	15·7	2·74
SiO_2	13·7	15·7					
	539·9	572·3		539·9	100·00	579·3	100·00

* Calculated.

Besides the above tabulated constituents the waters held a considerable quantity of organic matter, which was not estimated, a small amount of ammonia not exceeding one part per million and which if counted as sulphate would affect only slightly the relative proportions of calcium sulphate and carbonate, and in an unconcentrated state they gave no reaction with brucine or diphenylamine for nitrates or nitrites. Although cadmium was not found in the water from the West Spring, it is possible, in view of the close similarity of the two waters, that it was somehow overlooked.

In analyzing these waters a peculiarity deserves to be mentioned, which may at the same time serve as a warning to any one who may in the future examine them. Although a portion of the calcium unquestionably exists as carbonate, as shown by the excess of bases over chlorine and sulphuric anhydride, it is nevertheless the case that *all* the carbon dioxide is expelled by simply boiling the water. The amounts found for the East and West springs respectively were 120·5 and 110·0 parts of CO_2 per million. No more was obtained by acidifying the water. At the same time a precipitation of a zinc compound free from carbon dioxide and from calcium began to take place in the water as soon as the boiling point was neared, which soon ceased after ebullition set in. This precipitation furnishes the explanation of the total escape of carbon dioxide combined as well as free, from the unacidulated water; for as the calcium bicarbonate in solution becomes decomposed by heat the calcium carbonate at temperatures near the boiling point at once reacts with zinc sulphate with the formation of calcium sulphate, zinc hydrate or a very basic sulphate, and carbon dioxide. A determination of total solid constituents by evaporation of the water to dryness would involve therefore a very serious error in addition to those usually encountered.

A few remarks are here necessary in connection with the above reaction, which in one particular is so contrary to the statements which have come under my observations in chemical and geological literature bearing on the reaction which takes place between zinc salts in aqueous solution and undissolved calcium carbonate at elevated temperatures. It is generally stated that a basic zinc carbonate is precipitated while calcium sulphate goes into solution, except by Demarçay, the discoverer of the reaction, who says,* that zinc *oxide* is thrown down. It is not to be supposed that soluble calcium in the form of bicarbonate would in any way affect this reaction except to hasten its completion. While a zinc carbonate is undoubtedly thrown down

* Ann. d. Chemie, vol. xi, p. 250, 1834.

from a solution of the chloride by calcium carbonate, or by the bicarbonate as I have satisfied myself by experiment, this does not seem to be the case with a solution of zinc *sulphate*. An experiment, tested by repetition, with zinc sulphate and calcium bicarbonate in about the proportions shown in the above waters, *i. e.* with insufficient carbonate to throw out all the zinc, by observing which precaution no calcium carbonate can contaminate the precipitate, showed that the latter was absolutely free from carbonic acid and from calcium, but contained some sulphuric acid. If this is the normal reaction for the sulphate it is the one to be chiefly considered by the geologist, for in nature the sulphate of zinc and not the chloride, on which latter laboratory experiments seem to have been largely made, is the form in which that element is most likely to be found in solution.

The sediments from the bottles, which were very slimy, amounted when dried at 100° C. to approximately 17·0 parts per million of the water from the East Spring and to about 40·3 parts per million of that from the West Spring. They contained thus dried not less than 13 per cent of water and organic matter, while the ignition residue was about three fourths silica, and the remainder zinc oxide with a little iron, alumina, and sulphuric acid. The sediments were undoubtedly a mixture of amorphous silica, with very basic sulphates of zinc, aluminum and iron, without calcium. They had in both cases probably formed after the water was bottled, for they continued to appear in that portion of the filtered water which was retained as a reserve till completion of the analysis. As the two waters were not analyzed simultaneously the analyses are not strictly comparable, for one had deposited more sediment than the other, but it is noticeable that the water richest in salts had also deposited most sediment, showing that the differences in the analyses are not solely or in the main due to the different lengths of time that had elapsed between bottling and analyzing, but to inherent differences in composition.

With the waters was sent in a separate small bottle a sample of the precipitate deposited in the depression into which the springs emptied. It was contaminated by much decaying vegetable matter and admitted of no satisfactory quantitative examination, but after filtration and washing, qualitative tests showed it to be essentially the same as the deposit found in the bottles. Owing to its greater amount it was also possible to ascertain that cadmium, lead, and copper were to a certain extent concentrated in it.

The source of the metallic salt constituents of these waters is of course to be sought in one of the deposits of zinc blende

so numerous in that part of Missouri and across the State boundary in Kansas, although there are no known indications of zinc ores within a quarter of a mile of the springs and no large producing zinc mines within two miles of them. The limestones and cherts of the region supply the calcium and silica, and the organic matter, if not originally of surface origin, may well have come from oxidation of the bitumen which is found in quantity in the limestone. The permanent water level thereabouts is very near the surface, and it is not to be supposed that the particular waters under discussion have come from a great depth or are other than surface waters. The amount of zinc sulphate in them, however, is from two to three times as much as could have resulted under the most favorable conditions from oxidation of zinc sulphide either directly or indirectly by the sole agency of oxygen carried down by surface waters. It is probable, therefore, that the ore bed whence the supply of metals is derived lies very near the surface, above the permanent water level of the country, where the atmospheric oxygen has direct access to it through porosity of the earth's surface. The powerful influence of oxygen thus acting on moist ore-bodies, which have been exposed by the opening up of mines in changing the character of the waters of a region, is shown by E. Haworth* in writing of the mine waters of the adjoining county of Cherokee, in Kansas: "The well and spring waters before the mines were opened were first class, ... But as soon as the mines were opened all was changed, and the older the mines the worse the water. Animals of all kinds began being seriously affected," etc. He ascribes the high contents of the waters in metallic salts solely to the greater amount of oxidation rendered possible by exposure of masses of ore in the mine workings and on the dumps to atmospheric action, and gives instances to show how rapidly they succumb to it. He gives also a qualitative analysis of a mine water drawn from near the bottom of a shaft 130 feet deep which was nearly full of water at the time, and also the total weight of solids. The latter was over four times as high as in the spring waters above described, and there were found, in addition to the constituents already enumerated, ferric and ferrous sulphate in large quantity and free sulphuric acid. Carbonic acid, alkalies, and copper are not mentioned by him.

Laboratory of the U. S. Geological Survey, Washington, D. C., Jan. 1892.

* A contribution to the Geology of the lead and zinc mining district of Cherokee County, Kansas, presented to the faculty of the Kansas State University, 1884, p. 34.

Art. LIII.—*A Meteorite from Central Pennsylvania;** by Professor Wm. G. Owens.

The meteorite which I wish to describe at this time was found on or about the 25th of September, 1891, upon the east side of Bald Eagle mountain, seven miles south of the Park Hotel, Williamsport, Pa. At this point the mountain comes down to the edge of the Susquehanna river, a road-bed for the Philadelphia and Erie Railway having been cut in the mountain side. Numerous transverse depressions occur in the mountain side and some of these are filled with loose sandstone, varying in size from a few cubic inches to several cubic feet in volume.

It was in one of these depressions, several hundred feet from the railroad track, that some Italians, while getting out stones for a stone-crusher, found in a bed of loose stones about 2 meters ($6\frac{2}{3}$ ft.) deep, something which resembled a stone in appearance; it was covered with a fungus growth as were the stones, but when picked up attracted the laborer's attention on account of its weight. He showed it to the superintendent who tried to break it and failing attempted to cut it with a cold chisel, when it proved to be soft iron. After this it was again lost but soon after found. When, several weeks later, the owner of the crusher, Mr. George S. Matlack, class of 1870, came to the works it was given to him and he, realizing its value, presented it to this University. It weighs 3·3 kilos (7 lbs. 1 oz.) In shape it resembles in general outline a human foot. The flat face, corresponding to the sole, measures 16·6^{cm} ($6\frac{1}{2}$ inches) long and 8^{cm} ($3\frac{1}{8}$ inches) wide at the broadest place. From the extremity of the heel it projects upward 14^{cm} ($5\frac{1}{2}$ inches) ending in a point. The surface is covered with a reddish brown iron rust. This easily scales off in many places, and at several points this covering is so thin that the bright metal shines through. It is pitted quite deeply in some places, and very irregular in outline. On the projection above the heel there is a cavity about 1·5^{cm} ($\frac{5}{8}$ inches,) deep entirely burned out and almost opposite a core which has been only partially consumed.

There are several surfaces upon it which would seem to indicate that the objects which it struck in falling were flat. So even was the surface corresponding to the sole of the foot that when it was cut for etching not more than 2^{mm} ($\frac{2}{25}$ in.) had to be removed to get a surface of 32 sq. cm. (5 sq. in.). At the front there is also a surface of much smaller extent,

*Read before the Chemical Society of Bucknell University, Lewisburg, Pa.

which is perfectly flat and from it there projects a tip or point. Its specific gravity is 7·06. It is quite soft compared with iron. Most of the surface is covered with a very thin coating of rust. When polished and etched with dilute acid the Widmannstätten lines appeared very distinctly and beautifully. Chemical analysis gave: Fe 91·36, Ni 7·56, Co 0·70, P 0·09, S 0·06, Si, trace = 99·77.

Nothing is known as to the time of its fall, though as it was found covered by several feet of stones which have not moved sensibly since the Susquehanna Valley has been inhabited by white men it could not have been recent. As far as can be learned this is the only specimen of the fall which has been found.

ART. LIV.—*On two Meteoric Irons;* by GEORGE FREDERICK KUNZ and ERNEST WEINSCHENK, Ph.D. With Plate XIII.

1. *Indian Valley Township, Floyd County, Virginia.*

IN the spring of 1887 a mass of meteoric iron was turned up by Mr. John Showalter, while plowing his tobacco-patch, situated in Indian Valley Township, near the Carroll and Pulaski lines, and near the base of the south side of Floyd Mountain, six miles southeast of Radford Furnace, Virginia. He made careful search in the near vicinity for other pieces, but without success. This meteorite weighs thirty-one pounds, or fourteen kilos. It measures 28×20×13 centimeters, or 11×8×5 inches. The surface of the iron is very much corroded and is entirely covered with a limonite crust, very little of the original crust being visible. On the exterior are deep depressions from two to four centimeters in diameter. The iron is highly crystalline, and a piece was readily removed from an old fracture. When etched with hydrochloric acid it did not show the Widmannstätten figures.

The following analysis was made by Mr. L. G. Eakins, through the courtesy of Professor F. W. Clarke, of Washington, chief chemist of the United States Geological Survey.

Fe	93·59
Ni	5·56
Co	·53
Cu	*tr.*
P	·27
S	·01
Si	*tr.*
	99·96

The structure of this meteorite is very interesting, as it lies between the so-called breccia and hexahedral irons. Even on the unetched polished sides it is possible to identify the crystals of schreibersite arranged in bands lying parallel to the Neumann lines, which on the larger part of the mass are as well developed as in the Coahuila iron. Some parts of the piece exhibit a granular structure identical with that of Chattooga County.

As the Chattooga County meteoric iron was erroneously referred to the Coahuila iron by a writer* who had not seen the mass, the writers feel it their duty to rectify this, and to state that Chattooga County is over fifteen hundred miles northeast from where the nearest of the Coahuila masses was found.

It is a question whether the granular structure is the original structure out of which hexahedral particles were formed through re-crystallization, or whether it is due to the fact that this iron, not being rich in nickel, has a lack of crystallizing power; and it is impossible to decide. In any case this iron is not rich in nickel and cobalt.

The thanks of the writers are due to Mr. Walter Wood, of Philadelphia, for his courtesy in assisting one of us to obtain this meteorite and to ascertain the facts of its discovery.

2. *Sierra de la Ternera, Province of Atacama, Chile.*

This meteorite was kindly loaned to us by Dr. Moricke, of Stuttgart, Germany, who obtained it on a trip in Chile, with the information that it was found in the Sierra de la Ternera. The specimen is an elongated mass, and although small—weighing but 650 grams,—is undoubtedly the entire meteorite, as the unbroken original crust, beautifully preserved, and entirely covered with deep finger-like markings, would indicate.

Having received permission from the owner, one end was cut and polished; it was then found that dilute nitric acid scarcely attacked the iron, and only after heating was it possible to obtain distinct etching. The figures, however, were not characteristic. The ground-mass of this iron indicates a very compact structure on which there is to be observed a peculiar moire sheen, although this is not the character of the "Cape Iron," which it more nearly resembles, being a much more grained surface and by strong etching becomes easily dull. In this ground-mass are to be seen fine short sharply-drawn lines, which from their luster are very prominent. They are evidently not rhabdites, but are probably lamellæ of a nickel-iron mixture. In the chemical analysis, 0·44915 grams of this

* Proc. Amer. Acad. Arts and Sciences, Oct. 10, 1888, p. 34.

material dissolved in hydrochloric acid, which has been subjected to prolonged heating, afforded Dr. Weinschenk the following results:

Fe	83·02
Ni	16·22
Co	1·63
P	0·00
	100·87

The above analysis would place this iron near the "Cape Iron Group." As the physical properties of this group of irons have been so little studied, it is impossible for us to say whether the structure coincides or not. The complete absence of phosphoric acid, of which not a trace could be detected, indicates that this meteorite is an exception to the general rule in not containing the characteristic phosphor-nickel iron. To the best of our knowledge the occurrence of an iron in this group from Chile is new. It represents a new type, and possesses none of the many characteristics of the other known Chilean meteorites.

ART. LV.—*The Molecular Masses of Dextrine and Gum Arabic as determined by their Osmotic Pressures*; by C. E LINEBARGER.

PFEFFER'S *Osmotische Untersuchungen** have furnished until now the principal experimental support for Van 't Hoff's theory of solutions. The measurements of the osmotic pressures of cane sugar solutions agree as well as could be desired with the deductions from the theory. The monograph contains, however, the measurements of the osmotic pressures of several other compounds, such as saltpeter, potassium sulphate, cream of tartar, gum arabic and dextrine, and these determinations have been carried out with so much care and painstaking that considerable reliance may be placed on the accuracy of the results. As far as I know, no particular attention has been paid to these results. Yet the determinations of the osmotic pressures of dextrine and gum arabic afford a means for ascertaining their molecular masses. It is well established that dextrine has the formula $(C_6H_{10}O_5)_n$, and gum arabic is regarded as a salt resulting from the combination of several bases, as potassium, calcium and magnesium, with an acid

* Leipsic, 1877.

having the formula when dried at 100° $(C_{12}H_{22}O_{11})_n$. Nothing positive is known as to the numerical value of n. Let us see if Pfeffer's measurements will give us some information.

Pfeffer found that a 1 per cent solution of gum arabic* exercised an osmotic pressure of 7·2^{cm} of mercury at 16·1°. Applying the formula for dilute solutions, $pv = RT$, where p indicates pressure in grms. per cm^2, v the volume occupied by a molecule of the dissolved substance, R the constant, 84500, and T the absolute temperature, we have $p = 97{\cdot}2$ grms. per cm^2, $T = 289{\cdot}1°$ and $v = 100\,x$, where x represents the molecular mass of gum arabic. On solving, we obtain for x the value *2513*. This can be regarded as only approximately correct, for probably the gum arabic employed was not chemically pure. Now the molecular mass of a substance possessing the formula $C_{12}H_{22}O_{11}$ is 342, which multiplied by seven gives 2394. This does not differ greatly from the value obtained by experiment. As gum arabic when ignited leaves an ash amounting to 3–4 per cent of its weight and consisting of the carbonates of potassium, magnesium and calcium, the formula to be ascribed to the gum is not $(C_{12}H_{22}O_{11})_7$ but a similar one in which some of the hydrogen atoms are replaced by the above bases. This would so increase the molecular mass that it would approach nearer that found experimentally. We conclude then that the molecular mass of gum arabic is about 2500, and that the molecule consists of seven simpler molecules.

For dextrine,† Pfeffer found in 1 per cent solution an osmotic pressure of 16·6^{cm} of mercury at 15·6° C. Applying the formula, we have $T = 288{\cdot}6°$, $p = 225{\cdot}1$ grm. per cm^2 and $v = 100\,x$, solving, $x = 1083$. A substance of the formula $C_6H_{10}O_5$ has a molecular mass of 162; multiplying by seven, we obtain 1134, a number which agrees well with the one obtained by experiment. The molecular mass of dextrine is therefore 1134 and its formula $(C_6H_{10}O_5)_7$.

I recently‡ published the results of the determination of the osmotic pressure exerted by colloid tungstic acid, from which the molecular mass was calculated to be 1750 and the molecule $(H_2WO_4)_7$. It is remarkable that in these three cases, which as far as I know, are the only ones yet examined, the colloid molecule is *seven* times the simple molecule. This

* The gum arabic is stated as being "Bei 100° C. getrocknetes arabisches Gummi." Osm. Unt., p. 105.

† The following is the description of the dextrine employed. "Das Dextrin war als chemisch rein von der Fabrik bezeichnet. Da ich (Pfeffer) es aber nicht einer speciellen Reinigung unterwarf, so kann ich nur sagen, dass Traubenzucker, wenn überhaupt darin vorhanden, jedenfalls nur in minimaler Menge zugegen war." Osm. Unt., p. 112.

‡ In March number of this Journal, cxliii, 218.

seems to point to a more or less distant analogy with the periodic system of the elements, where likewise the number seven plays an important part. It will be interesting to see if subsequent determinations of the osmotic pressures of colloids will show this to be general. I am at present engaged in testing an apparatus for the rapid and accurate determination of the osmotic pressures of such substances as do not dialyze through parchment paper, etc., which will enable me to get at the molecular masses of the substances. These determinations will be carried out mostly with those substances treated of in Physiological Chemistry. When once the molecular masses of the complex colloid substances of animal and vegetable origin are known, a great stride in advance will have been made. As the value of an investigation of this kind depends upon the variety and number of substances examined, I take this opportunity to request those, who may have albuminoids or proteids of any kind, to kindly furnish me with a sample, in order that I may determine its osmotic pressure, and hence molecular mass. But a small quantity is necessary, two or three grams sufficing.

The results of Pfeffer's measurements fully confirm the observations made in my first paper on the nature of colloid solutions. Since its publication there has come to my notice an article by A. Sabanejew,* who has determined the lowering of the freezing point of solutions of egg albumin. The depression is indeed slight—in the hundredths of degrees,—but quite perceptible and sufficient to enable him to deduce the molecular mass of the albumin—14000. This proves that solutions of colloids as well as of crystalloids have a lower point of solidification than the solvent alone, and hence that the difference, if it exists, is only one of degree.

Recently, too, in an article on "Solution and Pseudosolution"† it is stated as one of the theoretical results of quite a series of experiments on the behavior of various colloid solutions that "there is a continuous series of grades of solution passing without break from suspension to crystallizable solution." The continuation of this work, which is promised, will probably throw much light upon the subject.

Chicago, Ill., 240 La Salle avenue.

* Jour. Russ. Soc., ii, 7 (1891).
† Jour. Chem. Soc., cccli, 171 (1892).

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Physical Properties of Fluorine.*—Having established the fact that when fluorine is free from hydrogen fluoride, it does not attack platinum at temperatures below 100°, Moissan has made use of containing vessels of this metal in order to determine the physical constants of free fluorine. By means of a platinum bottle of about 100 c. c. capacity, provided with a platinum tube passing through the stopper and having a lateral tube attached to the neck which could be closed by rotating the stopper, the density was determined. For this purpose the bottle after weighing was filled with dry nitrogen, and then with fluorine by displacement, the current being continued until the issuing gas readily ignited silicon. After a second weighing, the bottle was inverted in water, the oxygen set free by the fluorine was absorbed by alkaline pyrogallate solution, and the residual nitrogen measured. From the volume of the fluorine thus obtained, knowing the increase in the mass of the bottle, the density of the fluorine was easily found. Four determinations thus made gave values varying from 1·264 to 1·270 as compared with air; the value 1·265 being adopted by the author. Calling the atomic mass of fluorine 19·05, the theoretical density is 1·314. The color of fluorine was examined in a platinum tube a meter long and of about 200 c. c. capacity, having two lateral tubulures for the introduction of the gas, and closed at the ends with colorless plates of fluorite. Viewed against a white surface, the gas possessed a very distinct greenish-yellow color, weaker and more yellow than that of chlorine under the same conditions. No absorption bands were observed. The emission spectrum of fluorine was obtained by placing the gas in a platinum tube furnished with a lateral tube closed with a plate of fluorite, the electrodes at the ends of the main tube being insulated by the fluorite plates which closed these ends. Using an induction coil giving a 10^{cm} spark in air and placing a condenser in the secondary circuit, the spark in the fluorine was examined with a spectroscope having three heavy glass prisms. Both platinum and gold electrodes were used. With the former, thirteen lines of fluorine were observed, of wave-lengths 744, 740, 734, 714, 704, 691, 687·5, 685·5, 683·5, 677, 640·5, 634 and 623. The first three of these are very weak, the last four are strong. Of these only four, of wave-lengths 704, 640, 634 and 623 appear in hydrogen fluoride under the same conditions; while in silicon fluoride, ten of these lines, in phosphorus fluoride seven, in phosphoric fluoride six and in carbon tetra-fluoride the entire thirteen are visible. No trace of liquefaction was observed when fluorine was subjected to a temperature of −95° in a bath of solid carbon dioxide and

methyl chloride, at the ordinary pressure.—*Ann. Chem. Phys.*, VI, xxv, 125, Jan., 1892. G. F. B.

2. *On the Expansion of Chlorine in Violet Light.*—The observation of Budde in 1871 that chlorine suffers an expansion in volume on exposure to blue or violet light, has been confirmed by RICHARDSON who finds that this expansion is independent of the heating effect produced, and that it remains constant if the light is invariable, returning to its original volume when the light is cut off. By means of a differential apparatus, consisting of two glass tubes 10^{cm} long and of 55 c. c. capacity, connected to a graduated horizontal gauge having a small bulb at each end, this expansion was compared with the intensity of the light as determined with a Bunsen and Roscoe pendulum actinometer. The gauge and bulbs contained strong sulphuric acid, a bubble of air in the former serving as index. When these tubes, placed in a suitable box were turned so as to face the sun, it was found that when they both contained air, they were equally heated; but that when one of them was filled with dry chlorine, the expansion was greater upon this side. When the index became stationary the light-intensity was measured; and it was found that the change in the volume of the chlorine was very closely proportional to the intensity of the blue rays. By suspending such a differential apparatus on the beam of a balance so that the flow of acid from one side to the other caused this beam to move, a continuous registering apparatus was constructed by the author, the motion of the beam being communicated to a pen which produced a record on a revolving drum.—*Phil. Mag.*, V, xxxii, 277, Nov., 1891. G. F. B.

3. *On the Dissociation of liquid Nitrogen peroxide.*—OSTWALD has applied the generalization of Van 't Hoff, that dissolved substances obey the same laws as gases, to the data obtained by Cundall in a research upon the dissociation which nitrogen peroxide undergoes when dissolved in chloroform; expecting that the laws of dissociation of binary compounds such as this which are well known in the gaseous state, will also hold good for the dissolved peroxide. Representing by the equation $x^2/(1-x) = Kv$ the law of dissociation in the gaseous state, in which x is the amount of dissociated peroxide, v the volume of unit mass and K a coefficient constant with the temperature, the author obtains from Cundall's figures $v = 100/c$ and $x = 0{\cdot}000468r$, where c is the concentration and r the relative amount of NO_2 produced. Substituting these values the equation becomes $0{\cdot}000468r^2.c/1 - 0{\cdot}000468r = 100K$. And since K is constant when the temperature does not change, the first member must be also constant. The value of K as given from Cundall's figures varies from $2{\cdot}13 \times 10^{-7}$ to $3{\cdot}12 \times 10^{-7}$, the latter value being that at the highest concentration, and one at which Van 't Hoff's law can hardly be expected to hold with exactness. Hence it appears that nitrogen peroxide does in fact dissociate according to the same law whether it be in dilute solution or in the gaseous state,

the mean value obtained being $2{\cdot}31 \times 10^{-7}$. To ascertain whether at equal concentrations, the ratio of dissociation is the same in the gaseous and in the dissolved state, the author quotes Natanson to the effect that at 0° and a pressure of 250^{mm} ten per cent of the peroxide is dissociated. Under these conditions, the absolute density of the gas is 0·0014; *i. e.*, it corresponds to a 0·14 per cent solution of peroxide in a vacuum. From Cundall's experiments it appears that a 1·44 per cent solution at 0° contains 0·274 per cent of dissociated peroxide; and by Van 't Hoff's law a 0·14 per cent solution would contain only about one per cent of dissociated peroxide. In the gaseous state therefore the dissociation is so much farther advanced than it is in the chloroform solution, that to reach the effect of a vacuum the solution must be diluted to more than one hundred fold the bulk of the gas.—*J. Chem. Soc.*, lxi, 242, March, 1892. G. F. B.

4. *On a new method of preparing Carbonyl Sulphide.*—When carbonyl chloride is passed over heated cadmium sulphide, Nurıcsán has observed that carbonyl sulphide is formed. The carbonyl chloride must be carefully dried by passing it through sulphuric acid, and the finely divided cadmium sulphide contained in a hard glass tube, is to be mixed with asbestos to increase its surface. Although the action is perceptible even at ordinary temperatures, the author found that the best results were obtained at 360° to 280°. The gas evolved under these circumstances contained 94·87 per cent carbonyl sulphide, 3·98 per cent carbon monoxide and 1·15 per cent air. The tubes contained brilliant crystals which on analysis were found to be cadmium chloride. The reaction appears, therefore, to be a simple double decomposition according to the equation $COCl_2 + CdS = COS + CdCl_2$.—*Ber. Berl. Chem. Ges.*, xxiv, 2967, October, 1891.

G. F. B.

5. *On the Preparation and Properties of Cæsium.*—Beketoff has observed that cæsium is readily prepared by the action of aluminum upon its hydroxide. On heating 114 grams of the hydroxide with 27 grams of aluminum in a nickel retort and collecting the distilled metal in glass receivers, he obtained 25 grams of the metal. Its heat of combination with water was found to be from 50 to 52 calories. Cæsium hydroxide was prepared by precipitating pure sulphate with barium hydroxide and concentrating the filtrate in a silver dish placed a metal retort. On fusion, the dish was slightly attacked. It has a density of 4·0178 and a molecular volume of 37·3. Its heat of solution in water is 15876, which is higher than that of the other alkali hydroxides. Its heat of neutralization with hydrogen chloride is 13790.—*Bull. Acad. St. Petersbourg*, II, ii, 169, 171; *J. Chem. Soc.*, lxii, 274, March, 1892.

G. F. B.

6. *On the Color of Cobalt-Solutions.*—Etard has shown that the solubility-curves both of cobaltous chloride and cobaltous iodide consist of two portions intersecting at about the point where with increasing concentration the color changes. Hence

he concludes that they belong to two different hydrates. Moreover, CHARPY finds that the vapor-pressure curve for a 32 per cent cobaltous chloride solution also consists of two portions, the one belonging to the red solution extending to about 40°, while that of the blue solution begins at about 75°.—*C. R.*, cxiii, 699, 794, Nov., 1891. G. F. B.

7. *A method of showing Electrical Waves.*—LECHER has studied electric waves by means of a Geissler tube which is slipped along between parallel wires which are connected with condenser plates. At certain points the Geissler tube glows, and at nodal points it remains dark. L. Arons encloses a portion of the parallel wires, employed by Lecher, in a long vacuum tube of about 250^{cm} with a diameter of 6^{cm}. When the tube is exhausted to about 10^{mm} pressure, it is filled with light and dark spaces, which indicate electric waves. These waves are produced when there is a certain relation between the capacity of the condenser and the self induction of the wires.—*Ann. der Physik and Chemie*, No. 3, 1892, pp. 553–559. J. T.

8. *Permanent Magnetic Field.*—W. HIBBERT points out the use of a permanent magnetic field for various magnetic measurements, and gives the result of a peculiar arrangement which he has employed and which he recommends for testing purposes. A straight bar magnet is supplied at one end with a hemispherical pole-piece of soft iron, at the other end a soft iron disc is screwed which forms the cover of the hemispherical bowl. A circular air space of $\frac{1}{16}$ of an inch wide separates the cover of the bowl from its edges. A helix of wire surrounds the straight steel bar magnet in the interior of the bowl. By means of this helix the bar can be magnetized to any strength desired. A little coil of fine wire can be quickly thrust through the air space of $\frac{1}{16}$ of an inch which intervenes between the top of the bowl and its edges, thus cutting lines of force in a permanent magnetic field. Mr. Hibbert gives some figures which show the great constancy of this apparatus. There is practically no evidence of magnetic decay in seven months.—*Phil. Mag.*, March, 1892, pp. 307–314. J. T.

9. *Dielectric Constant and Conductivity.*—From experiments conducted by M. E. BOUTY, it appears that the dielectric constant only varies slightly under conditions which change the values of conductivity very greatly; thus water and ice have sensibly the same dielectric constant while the conductivity may vary from 1 to 10^6 or 10^6.—*Comptes Rendus*, March 7, 1892. J. T.

10. *Aberration.*—In a valuable paper on this subject, Lord RAYLEIGH reviews the work of experimenters on the subject of the hypothesis of a stationary ether or the reverse and thus speaks of Michelson's experiments to determine whether the ether is carried with the earth in its motion through space.

"It has recently been pointed out by Lorentz that Michelson has overestimated the effect to be expected according to Fresnel's views. The ray which travels perpendicularly to the earth's motion is not affected thereby, but is retarded to the amount repre-

sented by Dv^2/V^2. The outstanding relative retardation is thus only Dv^2/V^2 instead of the double of that quantity. Accepting this correction we have to expect, according to Fresnel's views, a shift of only ·024 of a band in Michelson's experiment. Under these circumstances Michelson's results can hardly be regarded as weighing heavily in the scale. It is much to be wished that the experiment should be repeated with such improvement as experience suggests. In observations spread over a year, the effects, if any due to the earth's motion through space would be separated. On the whole, Fresnel's hypothesis of a stationary ether appears at the present time the more probable, but the question must be considered to be an open one."—*Nature*, March 24, 1892. J. T.

11. *Kirchhoff's Law and the radiation of Gases.*—Kirchhoff's law is the theoretical fundamental law for the spectrum analysis of stars. It states that bodies emitting light absorb light of that wave length for which their emission spectrum shows a maximum. E. Pringsheim draws attention in an exhaustive article to the fact that the spectra of gases are generally studied by means of electrical discharges in Geissler tubes and that we have no direct evidence that mere increase in temperature suffices to make a gas glow. W. Siemens says in regard to this point: "To my knowledge investigations upon the question whether pure gases raised to a high temperature emit light rays have not been made." Siemens has shown that oxygen, carbonic acid, nitrogen and hydrogen, do not emit light rays even when heated to 1500° C.

Pringsheim therefore sets himself to determine:

1. Have gases the power to emit light merely from high temperature.

2. Can we form gaseous sources of light, which satisfy the conditions of Kirchhoff's law.

The conclusions he arrives at after much experimental work are the following:

1. There is no gaseous source of light which satisfies Kirchhoff's law.

2. Glowing gases, the temperature of which is below 150° C. can be obtained (cold flames).

3. The salts of sodium glow in flames only by means of chemical processes (reduction).

4. Metallic sodium heated in neutral gases, glows only from a chemical process.

5. The hypothesis that gas merely through rise in temperature can be made luminous, can be supported neither experimentally or theoretically.—*Ann. der Physik und Chemie*, No. 3, 1892, pp. 428–459. J. T.

II. Geology and Natural History.

1. *Note on the distribution of the upturned Cretaceous beds of British America*, by Dr. George M. Dawson. (Editorial Correspondence.)—To the north of the International Boundary

on the 49th parallel, the Cordilleran belt consists of four mountain systems, known, from northeast to southwest, as the Rocky Mountains proper, the Gold Range, the Coast Range, and the Vancouver Range, the last named being represented in a partially submerged form in Vancouver and the Queen Charlotte Islands.

This fourfold division does not continue in a definite manner as far as the 60th parallel, and still farther northward the ranges completing the Cordillera become even more diffuse and irregular. There is, however, throughout, and as far as the Arctic Ocean, an easterly bordering range, which though not entirely continuous, is homogeneous in general structure and is apparently identical in respect to the period of its main elevation, which must have occurred at a time immediately succeeding the Laramie.

This outer system is known as the Rocky Mountain Range proper. It has been most carefully examined in that portion of its length included between the parallels of 49° and 51° 30′ and particularly along the transverse line of the Bow River Pass, near the northern of the above limiting parallels. In this region the Cretaceous rocks, including the Laramie, have participated in the general upturning of the older strata, which has resulted in the definition of this system of mountains; and the Cretaceous rocks are often very violently flexed and disturbed and occasionally overturned.

Following the same mountain system to the northwestward, the still unconnected observations made in the vicinity of the Peace River, Liard River and again to the westward of the Mackenzie delta near the Arctic Ocean, show that the Cretaceous rocks have in all cases participated in the general uplift and disturbance, though in none of these places has the Laramie actually been recognized as a member of the folded strata. In the most northern and last-mentioned line of section, the Rocky Mountains are indeed almost entirely represented by flexed Cretaceous rocks.

Between the Rocky Mountain Range proper and the Pacific Coast, large tracts of the Cordillera appear to have resisted flexure and disturbance at this time, and it is practically certain that the Gold Ranges of the Southern part of British Columbia, together with many other considerable insular areas, have never even been covered by Cretaceous strata of any kind.

In the Coast Ranges, however, and for a variable distance inland from them, Cretaceous rocks, of a date at least as recent as the Dakota, have been subjected to violent flexure; and on the Lewes River, in the Yukon District, (Lat. 62° 20′, Long. 136° 10′), the Laramie is also present, and the older Cretaceous rocks appear to pass conformably up into this formation. In this northern region it is in fact clear that the Cretaceous sea at one time extended completely across the Cordillera, and rocks of Cretaceous age are frequently found to be upturned in association with older rocks, all having been affected by a common disturbance, apparently the latest of importance which has occurred.

On the seaward side of the Coast Ranges, the Cretaceous rocks, where they occur, are found likewise to have participated, to a considerable degree at least, in an upturning of the older strata; and on the inner side of Vancouver Island some of these rocks are probably of a date as recent as that of the typical Laramie.

2. *Preliminary Report on the Coal-deposits of Missouri from field work in* 1890 *and* 1891, by ARTHUR WINSLOW, State Geologist. 226 pp. with a map of the area of the coal measures and many wood-cut illustrations.—The area occupies the western and northwestern parts of the State and covers about 23,000 square miles. The rocks are sandstones and shales of various colors, the shales predominating, and they are horizontal or nearly so. The maximum thickness of the measures is 1900 feet. The coal beds are thin, and about a fourth of the annual Missouri supply, which amounted in 1891 to about 2,680,000 tons, comes from those that are not more than two feet thick. The Report treats of the origin of the coal measures and the special characters of the Missouri coal, and gives detailed descriptions of the beds that are worked.

3. *Baltimore, with an account of the Geology of its environs.* 140 pp. 12mo, with three maps and other illustrations. Prepared by the Local Committee of the American Institute of Mining Engineers, Baltimore meeting, February, 1892.—Nearly one-half of this little volume treats of the geology of the vicinity of Baltimore: the part on the crystalline rocks and their products is by Prof. GEORGE H. WILLIAMS of Johns Hopkins University, and that on the sedimentary rocks, by N. H. DARTON, of the U. S. Geological Survey.

The broad belt or plateau of crystalline rocks, lying to the eastward of the Appalachians,—the Piedmont plateau, as it has been called—is described by Prof. Williams as consisting of an eastern belt made up mainly of highly crystalline rocks and a western of semi-crystalline rocks. Of the latter it is stated there is reason to believe that they will yet afford fossils and have their age determined thereby. Small areas of the latter rocks occur also among the former. The conclusion reached with regard to the origin of the rocks is that the eastern rocks are in the main the older, and that over a floor consisting of such rocks, the beds of the western were deposited. The upturning and metamorphism of the latter are referred with a query to the time of the Appalachian mountain-making, but without mentioning evidence. The eastern lie within the range of the Archæan Appalachian protaxis. They include gabbro, both massive and schistose, pyroxenyte and peridotyte (rocks without any feldspar), with their alteration products, serpentine and steatite, granite, gneiss, crystalline limestone and quartzytic schist. All the massive rocks are made eruptive. Both the granite and gneiss contain coarse granite veins (pegmatyte), and, on very doubtful evidence, those in the granite are believed to be eruptive. Mr. Darton's contribution occupies 15 pages and treats of the formations of the

coastal plain. Two colored geological maps, by the U. S. Geological Survey, based partly on Mr. Darton's work, accompany the volume.

4. *Annuaire Géologique Universel: Revue de Géologie et Paléontologie*, dirigée par Dr. L. CAREZ et H. DOUVILLÉ.—The second and third parts of this very valuable Geological Annual, for the year 1890, have been published.

5. *Supplementary Appendix to Travels amongst the Great Andes of the Equator*, by EDWARD WHYMPER. 147 pp. 8vo, London, 1891, (John Murray.)—This Zoölogical appendix to Mr. Whymper's great work, contains contributions from fourteen zoologists, and four pages on the rocks by Prof. Bonney. The figures of insects are admirable. The highest flying butterfly and (with the exception of three or four beetles) the highest insect of any kind obtained, barring stragglers, is a Colias, described by Messrs. Godman and Salvin as *C. alticola;* it is the same species that was seen by Humboldt and Bonpland. It was collected at heights between 12,000 and 16,000 feet, and was observed still higher, or above the mean snow-line, which is about 16,000 feet in Ecuador. The Siluroid fish, *Pimelodus* (*Cyclopium*) *cyclopum* of Humboldt's Travels, and afterward described under half a dozen different names, was found to be of one species by Dr. F. Day, confirming thus the view expressed by Dr. Putnam in the American Naturalist, for 1871, p. 694. Five figures are given of it.

Prof. Bonney states that the specimens examined by him of the rocks of the volcanic mountains of the Western Andes, Cotocachi, Rucu-Pichincha, Corazon, Carihuairazo, Chimborazo and of the Eastern Andes, Cayambe, Antisana, Sincholagua, Cotopaxi and Altar were augite-andesytes containing more or less hypersthene; those of Pichincha, hornblende-andesyte, with micaceous andesyte at summit; of Iliniza, hornblendic augite-andesite, and the same for much of the Cayambe rock.

6. *Concerning principles which accompany chlorophyll in leaves.* ÉTARD (C. R. 1892, Feb. 15).—This paper points out the existence, in chlorophyll-bearing cells, of a triatomic alcohol, *Oenocarpol*, of a diatomic alcohol, *Vitoglycol*, and a monatomic alcohol, *Medicagol*. It shows, further, the presence in such cells, of a series of new crystallizable substances resembling cholesterine. There occur even crystallized paraffins; mixtures of these latter doubtless constitute the extractive matters which have been vaguely placed under the general appellation, "wax of leaves."

G. L. G.

7. *On the structure of the ovule and the development of the embryo-sac in Vincetoxicum.* CHAUVEAUD (Comptes rendus, 1892, Feb. 8).—The ovule in this plant appears on the placenta first of all under the form of a minute papula covered by epidermis. When this elevation has about five cells, the subepidermal cell in its axis increases very much in size, and its protoplasma acquires properties which distinguish it from its

neighbors. It becomes transformed directly into the embryonal sac. From the point of view of physiology, this ovule behaves nearly like ordinary ones, but examined from the point of view of morphology, it is wholly different from them, since it never has any true integument. It is absolutely naked.

In a subsequent paper, the author considers the fact of *polyembryony* in this plant. This phenomenon has recently excited considerable interest from the discovery of its occurrence in certain Leguminous plants (GUIGNARD, Ann. Sc. nat. 6 ser., t. XII, p. 35), in *Iris Sibirica* (DODEL, 1891, Zurich), and in *Lilium Martagon* (OVERTON, same date). The author is satisfied that the multiple impregnation in the case observed by him, was due to the division of the pollinic nucleus after its passage into the embryonal sac. He regards this as indicating that the pollen-grain of *Vincetoxicum* is comparable to a single antheridium producing the equivalents of antherozoids, here two or more generative nuclei. The author calls attention to the relations which this subject bears to the accepted notion as to the part played by the synergides. He points out also the greater symmetry of development of the embryos when there is only one present in the embryonal sac, and suggests that the suppression of polyembryony is on the direct line to the more perfect development of the species. G. L. G.

8. *Researches regarding the effect of leaf-removal in the case of grape-vines.* A. MUNTZ (C. R. 1892, Feb. 22.)—The author has sought to ascertain whether the practice of removing the leaves of the grape-vine just before the ripening of the grapes, is warranted by the results. His observations were made at Vergnes and Beaulieu, (Gironde), a district where this practice has been in vogue from time immemorial, and where it is regarded as indispensable to the proper ripening of the fruit. In general, his experiments show that defoliation is not followed by favorable results when the season is dry (like that of last autumn). It may be remembered that experiments by others have given conflicting results. In view of this M. Muntz inclines to hold his judgment in suspense as regards wet seasons, at least.

Among his incidental results are some which are truly surprising as to the elevation of temperature of the fruits exposed to the direct rays of the sun. But this elevation is not associated with a commensurate increase in the amount of sugar. In some instances there is no increase; there is on the other hand, a falling off in the amount of acidity. Pasteur has noted the latter fact with regard to wine placed in direct sunlight. G. L. G.

9. *The Italian Botanical Society* invites the botanists of every nationality to a general assembly in Genoa in order to communicate and to discuss the latest discoveries and new ideas and to increase good feeling amongst scientific men.

This Botanical International Congress will be held in Genoa from the 4th to the 11th of September this year 1892.

Nearer the time fixed a paper will be sent to botanists to which those wishing to attend will sign their names; at the same time they will receive a detailed program of the projected meetings as well as of the public excursions and festivities offered by the Municipality of Genoa to their visitors; the Italian Botanical Society will also offer its colleagues various excursions on the shores of the Mediterranean and in the Maritime Alps.

At the time of the Congress will also take place the inauguration of the new botanical institute built and presented to the University of Genoa by the munificence of the Comm. Thomas Hanbury, as also the opening of an exhibition of Horticulture, and of products exchangeable between America and Italy.

Italian botanists cordially invite their colleagues of every nation in order that their presence may render this Congress more important, and give it an essentially cosmopolitan character, for above all things it aims at strengthening by the powerful influence of science the bonds of fraternity between nations.

All enquiries and communications concerning the botanical congress should be addressed to Professor O. Penzig, R. Università, Genoa.

III. Miscellaneous Scientific Intelligence.

1. *Latitude Observations at Waikiki, on the island of Oahu, Hawaiian Islands.*—A recent number of the Hawaiian Gazette (March 8, 1892), contains the following account of the Latitude observations* now being carried on at Waikiki. The account is by Mr. E. D. Preston, of the U. S. Coast Survey, who is associated in the work with Dr. Marcuse of Berlin.

The latitude observations now going on at Waikiki were undertaken for the purpose of making a more exhaustive study of the motion of the earth's axis. German astronomers had recently detected a new movement of the pole from independent observations at several of their observatories, and in order to test certain theories in regard to the possible cause of the phenomenon it was proposed to make simultaneous observations on opposite sides of the world. The United States government was invited to join in the work, and, besides sending an observer to Honolulu, they enlarged the original plan by establishing stations at Washington and San Francisco. To the German government, however, belongs the credit of having first made a systematic study of the subject.

The motion of the pole is of course extremely small, and the effect is that here in Honolulu we are about fifty feet nearer the equator now than we were some months ago. This change does not, however, go on indefinitely, but the motion is such that the pole returns at the end of a year to nearly its original position. Besides this annual movement, there seems to be reason to believe

* See this Journal, xlii, 470, 1891, xliii, 163, 1892.

that there is a secular change extending over a period of at least sixty years.

It is evident that if observations on opposite sides of the earth show opposite phases, that is to say, if the Hawaiian Islands approach the equator at the same time that places in Europe recede from it, there is a strong presumption that the phenomenon is not a purely local one, but results from a real motion of the pole, affecting all places on the earth's surface. Indeed this latter fact now seems to be conclusively demonstrated from the observations up to date.

The method of work consists in observing, on every clear night, a list of stars in pairs whose positions are very well known; preference being given, other things being equal, to ones that were observed in England more than one hundred years ago, and whose motion since that time is therefore well determined. The stars, as far as they relate to the latitude work, were adopted in Berlin, and their selection was made the subject of careful study. In order to get the best possible result, certain relations must exist between the stars chosen, and this complicates the problem and makes their selection correspondingly difficult. For instance, in order that refraction may be small, nothing is taken beyond, say, 25 degrees from the zenith. In order that the image of the star be fine and well defined, only faint stars are admitted; and stars composing the same pair must be of about the same magnitude. Besides, if there is a certain relation between the distances of the stars from the zenith, the result is entirely free from any effect arising from an imperfect knowledge of the measuring apparatus. It is very desirable for several reasons to eliminate this effect. Then, again, the stars must not succeed each other too rapidly, in order that the measurements be carefully and deliberately made, nor on the other hand must they be too far apart. All these conditions should be satisfied at the same time, as far as practicable, which makes the selection of a perfect list of stars a somewhat tedious operation.

The great degree of refinement to which observations of this class are now brought, may be judged from the fact that although the observatories at Waikiki are only about thirty feet apart, this distance has a very perceptible effect on the result, and the observations continually show a difference of just this amount in the determined latitudes. However, for the study of the law of change of latitude, this is of no moment, for whatever the relative position of the points of observation they both change equally and verify the same law. The method employed, which is known as that of equal zenith distances, was first practically developed in the United States Coast Survey and is now universally adopted in work of this kind.

When the government at Washington was asked to coöperate in the Honolulu observations, it was seen that the occasion would be a favorable one for the study of several kindred subjects and the American representative in addition to the international lati-

tude work was charged with researches in gravity, magnetism, meteorology, etc. One of the theories proposed to explain the changes of latitude was that of transfers of large masses of molten matter in the earth's interior. In order to test this it was decided to measure the force of gravity every night that latitude observations are made, and this is now being done at Waikiki with an accuracy capable of detecting changes no greater than the one hundred thousandth part of the quantity measured. Practically stated we may say that a body falling toward the earth passes over about sixteen feet in one second; if from some unknown cause the force of gravity should change so as to increase this distance by only one-five hundredth of an inch, this slight increase would be easily detected by the methods employed.

To arrive at these results it is necessary to have a very accurate means of measuring time. This is done by referring all comparisons to the movement of the stars whose passages across the meridian are registered electrically on a revolving cylinder. A button is pressed when the star crosses a spider-thread stretched vertically through the field of the telescope, and instantly the fact is registered on the chronograph. The exact moment of transit can easily be known to within one-hundredth of a second. During the entire evening a pendulum is allowed to oscillate under the influence of the force of gravity. Means are used by which the duration of one vibration may be known with no greater error than a few millionths of a second. The gravity investigations are made for the sake of discovering whether there is any change in the force from day to day, and not for the purpose of knowing what the actual force is; in other words, the question is not how far a body will fall in a second, but whether it falls faster at one time than at another.

The methods followed are similar to those employed on Haleakala in 1887, which gave such conclusive evidence in regard to the formation of Maui, and which bore out Prof. Dana's geological theories. The same operations will be conducted next summer on Mauna Kea, and will throw light on its density and internal structure. This way of weighing the mountains has been employed many times in recent years. During the last cruise of the U. S. S. Pensacola to Africa, investigations were made on many of the islands of the Atlantic, which gave the interesting result that they are all comparatively light. The same instruments that were used in the African work were employed in these islands in 1887 and were sent to the South Seas with the U. S. Solar Eclipse Expedition in 1883, so that a fair portion of the earth's surface has been studied by the same method, which adds much to the strength of the result.

The present operations will close this fall, but the complete discussion of the observations will require probably a year more, so that the definitive results will not be known before the latter part of 1893.

2. *National Academy of Sciences.*—The following is a list of the papers entered to be read at the meeting of the Academy held in Washington, April 19–22.

G. K. GILBERT: An American Maar.

R. S. WOODWARD: The form and efficiency of the iced-bar base apparatus of the U. S. Coast and Geodetic Survey.

C. ABBE: On atmospheric radiation of heat in Meteorology. The astronomical, geodetic and electric consequences of tidal strains within an elastic terrestrial spheroid. Biographical memoir of William Ferrel. Biographical memoir of J. Homer Lane.

F. H. BIGELOW: On the deflecting forces that produce the diurnal variation of the normal terrestrial magnetic field.

C. A. SCHOTT: Abstract of results from the U. S. Coast and Geodetic Survey Magnetic Observatory at Los Angeles, Cal., 1882–1889, part III. Differential Measures of the horizontal component of the magnetic force.

A. S. PACKARD: On the anatomy and systematic position of the Mecoptera.

S. C. CHANDLER: On the laws of the variation of latitude. On the causes of variations of period in the variable stars.

T. C. MENDENHALL: On the force of gravity at Washington. On the recent variations of latitude at Washington.

A. M. MEYER: On the acoustic properties of aluminum, with experimental illustrations. Exhibition of Chladni's acoustic figures transferred to paper without distortion.

M. CAREY LEA: Disruption of the silver haloid molecule by mechanical force.

E. D. COPE: On the homologies of the cranial arches of the Reptilia. On the osteology of the genus Anniella.

E. S. MORSE: Asiatic influences in Europe.

M. I. PUPIN: On electrical discharges through poor vacua, and on coronoidal discharges.

J. W. POWELL: A definition of Institutions.

THEO. GILL: The partition of the North American Realm.

F. W. PUTNAM: Exhibition of teeth of a gigantic bear, probably an extinct species, found in ancient mounds in Ohio.

J. HOMER LANE: A means of measuring the difference between the tidal change in the direction of the plumb line and the tidal deflection of the Earth's crust. (A posthumous paper read by C. ABBE.)

OBITUARY.

SERENO WATSON.—The distinguished botanist, Sereno Watson, died at his home in Cambridge, Massachusetts, on the 9th of March. His career was a somewhat remarkable one because of the long period and varied discouragements during his early life before his distinctively botanical career began, and its contrast with the eminence he at last attained in this science. Mr. Watson was one of a large family of children, and was born at East Windsor Hill, Connecticut, December 1st, 1826. He graduated at Yale in the largest class up to that date, and which has given to American botany two other earnest students, Professor Henry Griswold Jessup of Dartmouth College, and John Donnell Smith of Baltimore, the latter widely known for his investigations of the flora of Guatemala. He entered college the third term of freshman year in the spring of 1844. Inquiry among his classmates shows that he was so retiring and reticent that they remember little about his college life other than that he was of gentle and retiring disposition, a diligent student, and that he

took prizes in Latin composition and Latin translation. After graduating he taught school, first in Scantic, Conn., and then on Long Island, and later in Rhode Island. While at Scantic he studied medicine two months with Dr. Watson of that place and again in the summer of 1849 with Dr. Sill of Windsor, and the next winter, attended lectures on medicine at the New York University. He left there in the spring of 1850 with, as he writes a friend, a diminished respect for medical practitioners, but with a high respect for the science. We next hear of him as teaching school in Allentown, Pa., and then in Tarrytown, N. Y. His diffidence made this work very uncongenial to him, and no one was more conscious of this than himself.

In 1852 his uncle, the Rev. Dr. Julius A. Reed of Davenport, Iowa, one of the founders and Trustees of Iowa College, invited him to that institution, where he remained as tutor two years. Before he had gone to Iowa, an elder brother, Dr. Louis Watson, a physician in practice in Quincy, Ill., had invited him to study in his office and enter practice there. He went there in July, 1854, studied with his brother, practiced medicine to some extent, and handled his cases well. But the practice was probably distasteful to him, for he gave it up in 1856, much to the regret of some of his patients. He then went to Greensboro, Ala., as Secretary of the Planters' Insurance Company of which his brother Henry Watson was President. He remained there until after the war broke out in 1861, and then came North and was engaged with Dr. Henry Barnard of Hartford in literary work, chiefly on the Journal of Education. When Dr. Barnard went to Washington as Commissioner of Education this service ceased, and in January, 1866, Mr. Watson entered the Sheffield Scientific School of Yale and pursued the studies of chemistry and mineralogy until the close of that college year and returned for a short time in the autumn. Here he worked very diligently in his scientific studies, but held little intercourse with his fellow students. Botany formed no part of his instruction while here. His studies were probably undertaken with reference to a possible residence in California, to which his thoughts were then turned, and he sailed for that State by way of Panama probably in March, 1867. He was at Sacramento late in April, and spent two or three months in the Sacramento Valley.

The Pacific Railroad was then in process of construction, and Clarence King had just entered upon the geological exploration of the 40th parallel. His party had left Sacramento in June, and had begun active work in the western part of the Great Basin. While Mr. Watson was in New Haven in 1866 Mr. King was also there a part of the time, and the proposed exploration of the region to be crossed by the much talked of Pacific Railway was the subject of frequent comment with the professors and students. The next year when Mr. Watson was at Woodville in the Sacremento Valley he heard that the expedition had set out, and he resolved to join it. From the terminus of the rail-

road he set out alone and on foot, crossed the Sierra Nevada and found his way to the camp of the party, which was then on the Truckee River below the present town of Wadsworth. The trip had been a hard one, and he was unused to mountains and deserts. He reached the camp weary, dust covered, and so foot-sore with his hard tramp that he carried his heavy boots with his luggage over his shoulder. The camp men were struck with his condition as he inquired for Mr. King, and he in turn was taken aback by the very youthful appearance of the commander of the party. He brought a letter of introduction from Dr. Barnard, whom Mr. King had known in Hartford, and was so earnestly anxious to join the expedition that he offered to accept any position the camp offered if there was no scientific work for him. He was engaged to assist in topography, observe the barometer and make himself useful as he could, at first on a mere nominal salary. Mr. W. W. Bailey was the botanist of the expedition, but he was already weakened by fever and could illy stand the hardships of collecting in a desert region. Watson began to collect plants immediately in connection with his topographical work. He had a general knowledge of botany, probably picked up years before while studying medicine, but the plants of that desert region were all new to him, and excited his intense interest. His untiring diligence, his keen observation of plants, his cheerful endurance of the discomforts and hardships of desert campaigning soon gave evidence of his scientific zeal, and personally endeared him to the whole camp, and when finally, before the close of that season, Mr. Bailey succumbed to the hardships of the work, Mr. Watson was chosen to succeed him.

That season and the following winter was spent in the western part of the Basin and the summer of 1868 in the Humboldt mountains and other parts of eastern Nevada. The next winter he spent at New Haven in the Herbarium of Professor Eaton at work upon his collection. He returned to the field and spent the summer of 1869 in Utah. He apparently was happier in this field work than he had ever been before. His comrades speak of his enjoyment of the wild natural scenery of the region he was exploring, and of the various natural phenomena there occurring. He was particularly and intensely interested in the desert vegetation. He was fearless and intrepid in his work; sometimes bivouacked in solitude over night in the mountains, returning the next day with his botanical treasures, always calm and cheerful and undemonstrative.

He returned to New Haven in the fall of 1869, and remained with Professor Eaton about a year, at work on his collection, and went to Cambridge late in 1870 to finish the work at the Gray Herbarium.

His Report was finished in 1871, and was the most complete nd extensive botanical report of any of the exploring expeditions on the Pacific slope.

From this time on he remained at Cambridge, and soon became the Curator of the Gray Herbarium. Here was a sphere just

fitted to his nature and training, the working up of some of the more difficult problems of North American Botany. His keen observation and untiring industry, his long and varied training and diversified experience peculiarly fitted him for the work which had at last fallen to him. His intensely conscientious devotion to truth showed itself alike in his scientific work and in his personal life and habits.

After his report was finished the writer, who was then at work on the Botany of California, induced him to finish and publish a list of references he had begun, and later to finish the work on the Botany of California which had been begun by others.

The results of his botanical work during the last twenty-one years of his life are published in too many papers to be given in detail here. They may be summed up as follows: (1) The Report of the Botany of the 40th Parallel; (2) Bibliographical Index to North American Botany; (3) In coöperation with others, The Botany of California; (4) Eighteen contributions, mostly monographs, published in the proceedings of the American Academy of Arts and Sciences; (5) In coöperation with President Coulter of Indiana, a Review of Gray's Manual; (6) A Manual of the Mosses of North America; a work left unfinished by James and Lesquereux; (7) The Botanical definitions in the earlier part of the Century Dictionary. Dr. Watson made only two considerable botanical trips during these later years; one to the Northwest in connection with the forest work of the Census of 1880, and a trip to Guatemala in 1885.

After the death of the lamented Asa Gray he took up the task of completing the Synoptical Flora. For this, his long companionship with Dr. Gray eminently fitted him, but like his illustrious predecessor he was not spared to finish the work. An attack of the prevailing influenza followed by pneumonia and cardiac complications brought his eminently useful and laborious life to an end on March the 9th.

Had he died twenty years after graduation the world would have known little of him, and his classmates would have considered his life a failure. That long period was, however, years of diversified preparation, which fitted him to bring to his chosen work most thoroughly trained powers, and gave him a wide range of knowledge drawn from the study of several sciences, and a personal knowledge of the aspects of the flora of many and widely separated parts of the country. The reserve which characterized him in college, and which lasted through life, left him all the more free to prosecute his chosen work without the distractions of society. But his reticence was not that of the misanthrope. He endeared himself to all who were brought in close relations with him. This was as strikingly shown in the trials and hardships of camp-life, as among the inner circle of his friends in the University, and in the few families that had the privilege of his acquaintance. His death has left a gap among the American systematic botanists which will not soon be filled. W. H. B.

APPENDIX.

ART. LVI.—*A New Order of Extinct Eocene Mammals (Mesodactyla)*; by O. C. MARSH.

DURING explorations in the lower Eocene deposits of New Mexico, carried on by the writer in 1876–1880, some of the first fossils discovered were remains of small mammals about as large as a fox, and of much scientific interest. The teeth are somewhat similar to those of Ungulates, but the rest of the skeleton, and especially the limbs and feet, are of a generalized type quite distinct from any of hoofed animals known, recent or extinct. Some parts of the structure seem to indicate an affinity with *Hyrax*, but the limbs and feet show characters resembling those of the Primates, especially the extinct forms, and likewise seen in Insectivores, and even in some of the Rodents. A large collection of these remains was secured, and when examined was found to include several distinct forms, all of small size, and forming together a natural group.

One of these forms was described by Cope, under the name *Meniscotherium chamense*, the type being a portion of an upper jaw, with the molars in place.* This specimen was subsequently described and figured by that author, who regarded it as belonging to the Perissodactyles.† Later, he defined two additional species, and proposed for the family the name *Meniscotheriidæ*; and more recently has described and figured various parts of the skull and skeleton.‡

Several other authors since then have discussed the affinities of this peculiar family, but mainly without presenting any new facts bearing on the question, the general opinion being that these animals are primitive forms of *Perissodactyla*, more or less related to *Chalicotherium*, Kaup, which genus they resemble in dentition. A comparison of the feet would have been more important, but those of *Meniscotherium*, at least, were unknown.

* Report of Chief of Engineers for 1874, pt. ii, p. 596.
† Extinct Vertebrata, p. 251, pl. lxvi, 1877.
‡ Tertiary Vertebrata, 1884.

The large collection of the remains of this group secured by the writer contains almost every part of the skull and skeleton, pertaining to many individuals. Among these are specimens which agree closely with the types described and figured by Cope, as well as a number of others that are evidently quite distinct. Besides *Meniscotherium*, a second genus is represented, which may be called *Hyracops*, and its typical species is described below. This genus is more specialized than *Meniscotherium*, and may be from a somewhat higher horizon of the lower Eocene, but the two genera are found in the same region, and may perhaps occur together.

An investigation of all the specimens represented in this collection of the writer makes it evident that they pertain not merely to a distinct family, but to a separate order, which may be called the *Mesodactyla*. The skull and teeth resemble strongly those of the *Ungulata*, especially some of the early Perissodactyles, but the limbs and feet prove these fossils to be quite distinct from any hoofed animals hitherto known.

The skull of *Hyracops*, in its general form, resembles that of *Didelphys*. The premaxillaries do not reach the frontals. The latter are wide between the orbits, and there is a small postorbital process, behind which the skull is much constricted. There is a strong sagittal crest. The malar reaches the lachrymal. The palate is complete, and the posterior nares extend forward to the penultimate molar. The brain was of moderate size, with the olfactory lobes and the cerebellum especially developed, and not at all covered by the cerebral lobes.

The dentition of the *Mesodactyla* is of special interest. The teeth are brachydont, the molar series lophodont, with external and internal crescents and intermediate cusps, with deep valleys. In one genus, with which the type specimen of *Meniscotherium* best accords, the premolars are unlike the molars. In the genus *Hyracops*, the last premolar is nearly or quite like the molars.

A striking feature in the dentition of both genera is the succession of the teeth. The first series of incisors, canines, and premolars, appears to be retained for a long period. This is certainly the case with the premolars, which continue in use until long after the three true molars have come into service. This fact confirms the recent researches of Kükenthal on *Didelphys*, and indicates that the supposed true molars may belong to the first dentition.

The vertebræ have their articular faces nearly or quite flat, and in the cervical region, these are oblique. The sacral vertebræ are firmly coössified, and are three in number in *Meniscotherium*, while in *Hyracops* there are four. The sternal bones are flat.

The fore limbs were somewhat shorter than those behind. The humerus is stout, of moderate length, with its distal end much flattened, and a supracondylar foramen. It resembles the humerus of a carnivore rather than that of an ungulate. The radius and ulna are nearly equal in size. The head of the radius is expanded transversely, and closely applied to the ulna, indicating but little rotation. The ulna is a stout bone, with the distal end compressed and pointed. The carpal bones resemble in general form and position those of *Hyrax*, and a central bone is present in the same place as in that genus. The five metacarpal bones are all well developed, and their position with reference to the carpals that support them is shown in the fore foot of *Hyracops* represented below in figure 1.

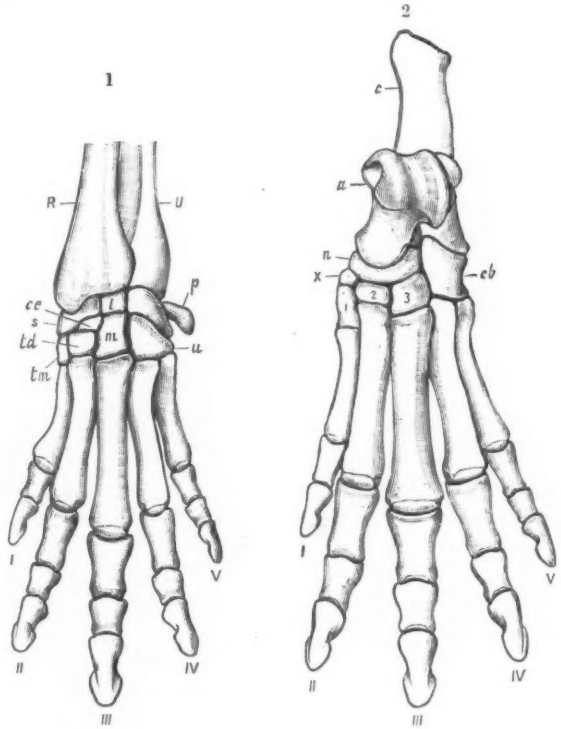


FIGURE 1.—Left fore foot of *Hyracops socialis*, Marsh.

FIGURE 2.—Left hind foot of same species. Both natural size.

a, astragalus; *c*, calcaneum; *cb*, cuboid; *ce*, central bone; *l*, lunar; *m*, magnum; *n*, navicular; *p*, pisiform; *R*, radius; *s*, scaphoid; *td*, trapezoid; *tm*, trapezium; *U*, ulna; *u*, unciform; *x*, epicuneiform.

The feet are primitive in type, and were apparently digitigrade, yet the terminal phalanges were not encased in hoofs or in claws, but possessed an intermediate character, which has suggested the ordinal name. Their extremities are thin, somewhat expanded, and more like those of Primates than of any other group. They were apparently covered by thin nails.

The femur has a third trochanter, near the middle of the shaft. The tibia resembles that of a carnivore. The fibula is complete, well developed, and at its distal end is expanded, and meets both the astragalus and the calcaneum.

The hind foot is represented in figure 2, and presents several points of interest. The astragalus and calcaneum are very similar to those in Rodents. The navicular is supported entirely by the astragalus, and the cuboid by the calcaneum. On the tibial side below the navicular, and supported by it, is a small bone (x) having beneath it the entocuneiform. It meets the middle cuneiform also. This bone has apparently not been known hitherto, and may be called the epicuneiform. It may, perhaps, correspond to what is known as the tibial sesamoid in Rodents and Carnivores, but its position and connection in the present tarsus are quite different. Moreover, a distinct tibial sesamoid is also present inside and behind the epicuneiform, and hence not shown in the figure.

In the feet of *Meniscotherium*, there are five well-developed digits in manus and pes. The structure of the carpus and tarsus agrees in general with that of *Hyracops*, but in some points, there appear to be differences of importance.

The order *Mesodactyla* contains at present the two genera *Meniscotherium* and *Hyracops*, which include primitive mammals of small size, having the full number of forty-four teeth in continuous series, with the premolars and molars similar in type to mammals known as Ungulates. The limbs and feet are primitive in type, unlike those of any known Ungulates, and resemble those of Carnivores, or the early Primates.

This order stands in somewhat the same relation to the typical Ungulates that the *Tillodontia* do to Rodents, and the *Chalicotheria** to Edentates. Very briefly defined, the *Mesodactyla* may be considered as having the ungulate type of dentition, with the limbs and feet of early Primates; the *Chalicotheria* as combining an ungulate dentition with the feet of Edentates; while the *Tillodontia* unite with the rodent dentition the extremities of primitive Carnivores. These three orders are quite distinct from each other and from the remain-

* The name first proposed for this order, *Chalicotheroidea*, Gill, 1872, may appropriately be shortened to *Chalicotheria*. The term *Ancylopoda* more recently given is preoccupied. The genus *Moropus* is not identical with *Chalicotherium* as has been stated, and *Morotherium*, which has also been referred to the latter genus, is a true Edentate allied to *Mylodon*.

ing *Mammalia*. All three have certain points of resemblance, but differ widely in other respects. Their exact relations to each other and to other mammals are still uncertain, but future discoveries may at any time clear the matter up.

One fact is becoming more and more evident, the near affinity of the early Primates, Carnivores, Ungulates, and Rodents, with each other and with the Insectivores, and more remotely with Marsupials. The key to the mystery lies concealed in the great break between the lower Wahsatch, at the base of the Eocene as now known, and the Laramie beds of the Cretaceous. In the latter, none of the above placental mammals have been found, but in the early Eocene occur, side by side, Carnivores, Rodents, and Ungulates, the last represented by both typical Perissodactyles and Artiodactyles, and even some of their subdivisions. The *Amblydactyla* of large size, the *Tillodontia* also large, and the diminutive *Mesodactyla*, all apparently lived together in this period, and a comparison of their special characters points out their probable lines of descent. The convergence of these lines makes every discovery in the earlier geological horizons of importance, and a connection with the Mesozoic *Mammalia* may at any moment be demonstrated. The Edentates are evidently a later development, as are also the Sirenians and Cetaceans.

New Haven, Conn., April 16, 1892.

Art. LVII.—*Notice of New Reptiles from the Laramie Formation;* by O. C. Marsh.

Among the extensive collections of vertebrate fossils secured during the last few years from the Ceratops beds along the eastern base of the Rocky Mountains, remains of reptiles largely predominate, and many have already been described by the writer. A number of new forms of much interest have recently been secured, and some of these are briefly noticed below. The presence of Ophidians and true Lacertilians among the gigantic forms of *Dinosauria* is especially noteworthy, as their discovery has long been expected. The new Dinosaurs described confirm previous indications, that this subclass, before its extinction, developed into many highly specialized forms, of which suggestions, at least, were seen in those from lower horizons. The large number and variety of these specialized forms could hardly have been anticipated, and they make prominent the probability that the Reptilian age reached its culmination near the close of the Cretaceous.

Coniophis precedens, gen. et sp. nov.

The earliest serpents hitherto known in this country are included in the genera *Titanophis* (*Dinophis*) from the marine Eocene of New Jersey, and *Boavus* from the fresh-water Dinoceras and Coryphodon beds of the West, both described by the writer.* None have hitherto been found in the American Cretaceous, and but one species is known from Europe.† The type specimen of the present genus and species is the vertebra represented below in figure 1. Several others were found at the same locality, but may not pertain to this individual.

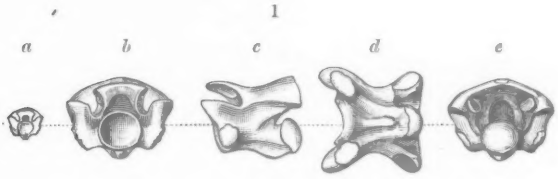


FIGURE 1.—Vertebra of *Coniophis precedens*, Marsh.
a, natural size; *b*, *c*, *d*, *e*, three times natural size.

In the type specimen figured above, the zygosphene articulation is fully developed, and all the characteristic Ophidian features are distinctly shown. The nearer affinities of the genus will be discussed in a later communication. All the known remains of the species are from the Ceratops beds of Wyoming.

Chamops segnis, gen. et sp. nov.

The type specimen of the present genus is the maxillary bone with teeth represented in figures 2 and 3 below. Various other parts of the skull and skeleton have been found at different localities in the same horizon, but it is not certain that they pertain to the same species. Dentary bones with precisely similar teeth, and corresponding in size with the jaws figured, have been secured, and there can be little doubt of their identity. Among the other portions of the skull obtained is the upper part of the cranium. This has the surface very rugose, and is perforated by a large parietal foramen.

* This Journal, vol. xlviii, p. 397, November, 1869; and vol. i, p. 322, May, 1871.
† Sauvage, Compte Rendu, t. xci, p. 671, 1880.

Various vertebræ found at the same localities may be referred to this species. They are procœlian, with the cup and ball transverse, and oblique. These are all without the zygosphene articulation.

2 3

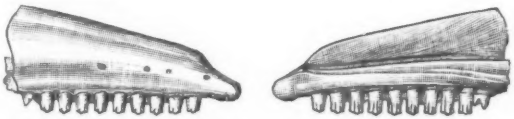


FIGURE 2.—Maxillary of *Chamops segnis*, Marsh; outer view.
FIGURE 3.—The same bone; inner view. Twice natural size.

The remains of the species here described are all from the Laramie of Wyoming.

Iguanavus teres, sp. nov.

Another Lacertilian, much smaller than the above, left its remains in the same horizon. The specimens best preserved are vertebræ, which agree in general form of the centra with those just described, but possess the zygosphene articulation. They are about the size of the Ophidian vertebra above described, but may readily be distinguished by the oblique and transversely expanded articular faces, and by the smooth under surface of the centrum. The type specimens are all from the Laramie of Wyoming.

Ornithomimus sedens, sp. nov.

The remarkable Dinosaurs described by the writer, and referred to the present genus, representing a distinct family, were mainly from fragmentary remains, but differed widely from all forms then known.* Since then explorations in the same horizon further north have brought to light various other specimens, which prove the group to be of great interest, but make it probable that they should be referred, not to the *Ornithopoda*, but to the *Theropoda*.

The present species is based upon the nearly complete pelvis, with various vertebræ, and some other parts of the skeleton. The most striking feature of the pelvis is the fact, that the ilium, ischium, and pubis are firmly coössified with each other, as in recent birds. This character has been observed

* This Journal, vol. xxxix, p. 84, January, 1890.

hitherto among Dinosaurs, only in the genus *Ceratosaurus* described by the writer from the Jurassic of Wyoming.* The present pelvis resembles that of *Ceratosaurus* in its general features, but there is no foramen in the pubis.

There are five vertebræ in the sacrum, firmly coössified with each other, as are also the sacral spines. The sacral vertebræ are grooved below, with the sides of the centra excavated. The caudals have the diplosphenal articulation, and the first caudal bears a chevron. All the bones preserved are very delicate, and some of them, at least, are apparently pneumatic. The sacrum measures fifteen inches in length, and the twelve caudals following occupy a space of thirty-one inches. The known remains indicate a reptile about eight or ten feet in length.

In the same horizon occur the remains of a very minute species, which agrees in all its characters, so far as determined, with the members of this genus. The most characteristic portions secured are the metatarsal bones, and these show the same features exhibited in the type species of the genus, *O. veloæ*. They are, however, so much smaller as to suggest that they may pertain to a bird. Various portions of the second, third, and fourth metatarsals are known, and the distinctive feature is seen in the third, which has the upper part of the shaft so attenuated that it may not reach to the tarsus. The second and fourth metatarsals are very long and slender. This unique fossil, when alive, was about the size of the common fowl. The species may be called *Ornithomimus minutus*.

The large species described by the writer as *Ornithomimus grandis* belongs in essentially the same horizon. Portions of two other skeletons have since been obtained, which apparently pertain to this species. In one of these, the femur, tibia, and fibula are in good preservation, and they clearly demonstrate that this reptile was one of the largest of the *Theropoda*. The femur and tibia have each a very large cavity in the shaft, with well-defined walls. Even the fibula has a cavity in its upper portion. In the other specimen, the second metatarsal is in fair preservation, and shows the same form as in the type of the genus.

There is much probability that this gigantic carnivore was one of the enemies of the *Ceratopsidæ*, and the discovery of the entire skull and skeleton will be awaited with interest, as they will doubtless show special features for offense, which the peculiar defensive armor of the *Ceratopsidæ* was designed to meet.

The known remains of all the above species are from the Ceratops beds of Wyoming.

* This Journal, vol. xxvii, p. 329, April, 1884.

Claosaurus annectens, sp. nov.

The reptiles of the Laramie allied to *Hadrosaurus* are numerous and highly specialized. One of the forms most distinct, but not abundant, is here described, and the type specimen is a nearly complete skull and skeleton. This will be fully described by the writer, but as the pelvis presents some points of interest it is represented in figure 4 below. The ilium exhibits no special characters of importance, and agrees in the main with the corresponding bone of the type of the genus. The ischium is especially elongated, and very straight. The pubis is represented by a very large, expanded prepubis, and a mere remnant of the postpubis, as is well shown in the figure.

4

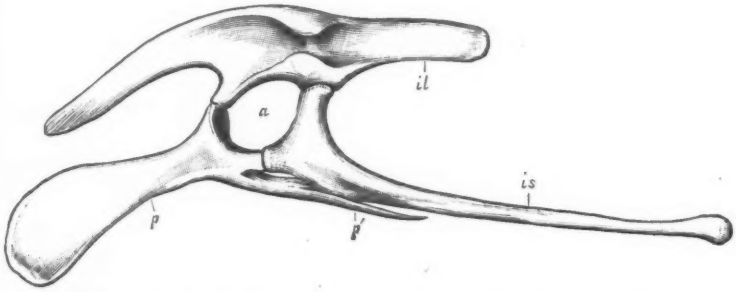


FIGURE 4.—Pelvis of *Claosaurus annectens*, Marsh. One sixteenth natural size. *a*, acetabulum; *il*, ilium; *is*, ischium; *p*, pubis; *p'*, postpubis.

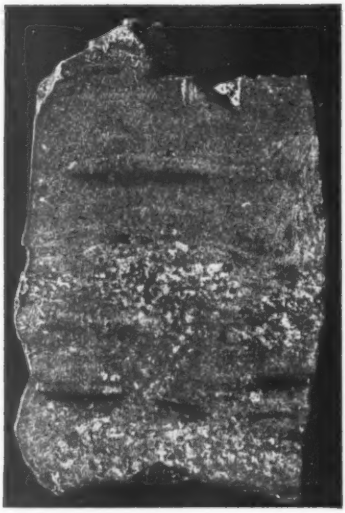
This important specimen is from the Laramie of Wyoming.

The fossils described in the present article were all collected by Mr. J. B. Hatcher, whose discoveries in the Rocky Mountain region are well known to paleontologists.

New Haven, Conn., April 18, 1892.

1.

2.



3.

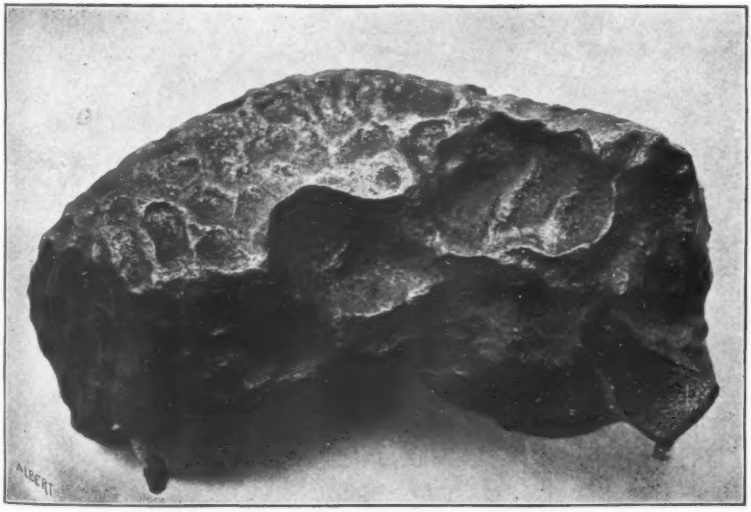


FIG. 1.—An etched section of the meteoric iron from Floyd Mountain. In this the hexahedral structure of the iron is prominent on a larger part of the surface. In a few places this is broken by the granular particles. Very prominent are the parallel markings of the elongated rhabdite crystals.

FIG. 2.—A similar etched section from nearer the interior of the mass. In this mass the granular particles are more plentiful. The sheen is more apparent in diagonal bands.

FIG. 3.—A natural sized view of the meteoric iron of Sierra de la Ternera, showing the finger-like markings and depressions with which the entire mass is covered.

THE MICROCOSM.

MINERALOGY, GEOLOGY, ZOOLOGY.

RELIEF MAPS.

Especial attention given to Relief Maps. All work of this kind executed accurately and artistically. Can also furnish copies of models made for the Government: Grand Cañon of the Colorado, Yosemite Valley, Wasatch and Uinta Mountains, Mt. Taylor, Mt. Shasta, Leadville, Eureka, etc., etc. Also model of the whole United States with ocean bottoms adjoining, modeled on the correct curvature.

MINERALS.

My stock of minerals is very large and complete, sold as individual specimens or systematic collections of all sizes. The $100 collection is adapted to the higher grade of Academies.

METEORITES.

If you wish to buy or sell meteorites or to have them cut and polished write me.

ANATOMICAL MODELS, TAXIDERMY, &c.

EDWIN E. HOWELL,

537 15th St., N. W. Washington, D. C.

BECKER BROTHERS,

No. 6 Murray Street, New York,

Manufacturers of Balances and Weights of Precision for Chemists, Assayers, Jewelers, Druggists, and in general for every use where accuracy is required.

AMERICAN JOURNAL OF SCIENCE.

FOUNDED BY PROFESSOR SILLIMAN IN 1818.

Devoted to Chemistry, Physics, Geology, Physical Geography, Mineralogy, Natural History, Astronomy, and Meteorology.

EDITORS: JAMES D. DANA and EDWARD S. DANA.

Associate Editors: J. P. COOKE, JR., GEORGE L. GOODALE, and JOHN TROWBRIDGE, of Cambridge, H. A. NEWTON and A. E. VERRILL, of Yale, and G. F. BARKER, of the University of Pennsylvania, Philadelphia.

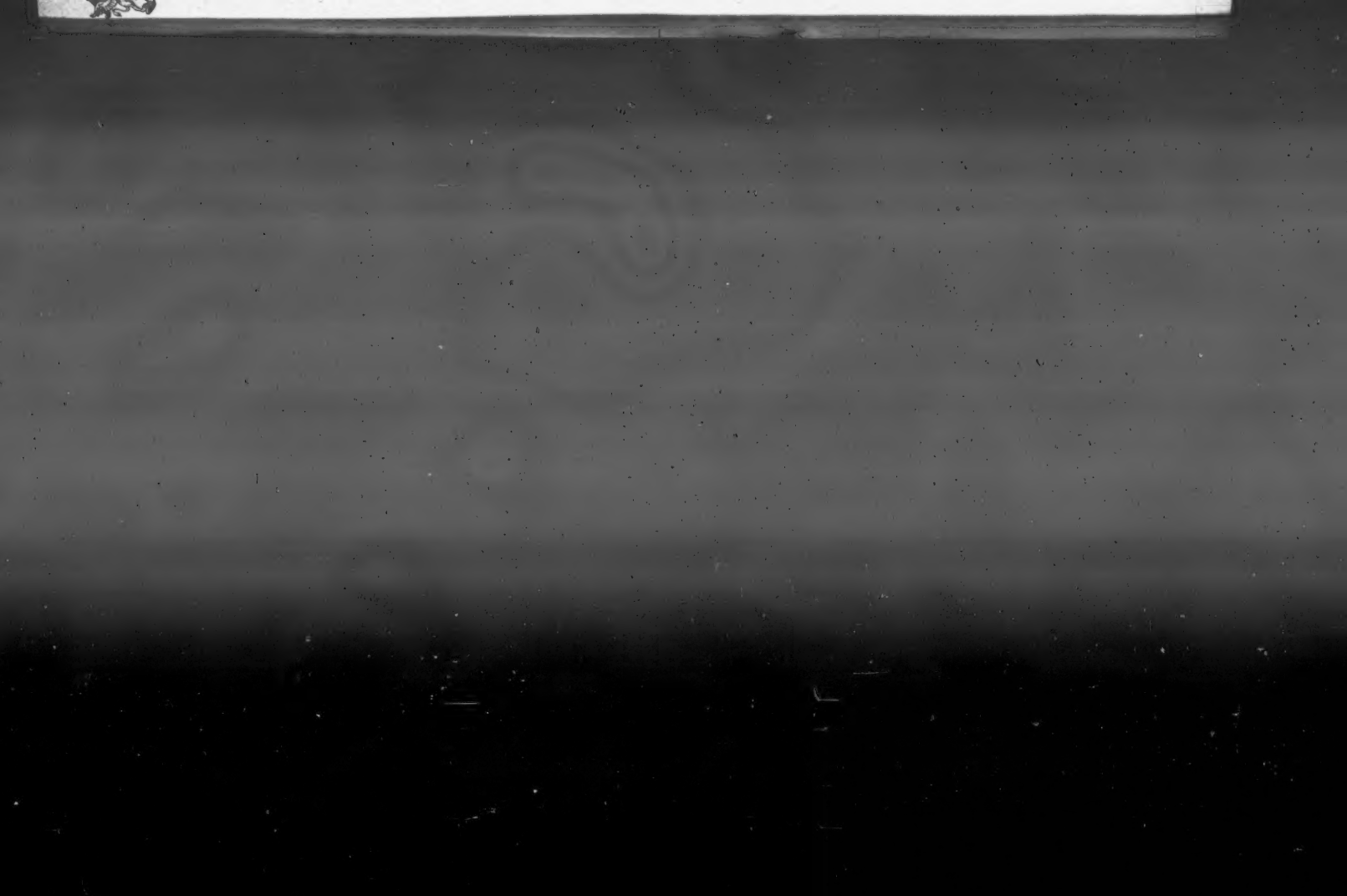
Two volumes of 480 pages each, published annually in **MONTHLY NUMBERS.**

This Journal ended its *first* series of 50 volumes as a quarterly in 1845, and its *second* series of 50 volumes as a two-monthly in 1870. The monthly series commenced in 1871.

Twenty copies of each original communication are, *if requested in advance*, struck off for the author without charge; and more at the author's expense, provided the number of copies desired is stated on the manuscript or communicated to the printers of the Journal.

Address the PROPRIETORS,

J. D. and E. S. DANA, New Haven, Conn.



Im Verlage von **Johann Ambrosius Barth** in **Leipzig** ist erschienen:

Untersuchungen

über

die Ausbreitung der elektrischen Kraft

von

Dr. Heinrich Hertz,

Professor der Physik an der Universität zu Bonn.

17 Bogen mit 40 Figuren im Text.

Preis 6 Mark.

Die Arbeiten, durch welche Professor Hertz vor einigen Jahren zum erstenmale die zeitliche Ausbreitung einer vermeintlichen Fernkraft nachwies, und die Maxwellsche Theorie über den Zusammenhang der elektrischen Erscheinungen mit dem Lichte durch Versuche erläuterte, sind in den „Annalen der Physik und Chemie" erschienen. Da einzelne Hefte dieser Annalen nicht abgegeben werden können, so war die Verlagsbuchhandlung nicht in der Lage, die häufig an sie herantretenden Wünsche nach jenen Arbeiten zu befriedigen. Deshalb erscheinen jene Arbeiten hier aufs neue in gesammelter Form. Der Verfasser hat den Abhandlungen eine einleitende Übersicht vorausgeschickt, durch welche er den inneren Zusammenhang der einzelnen Arbeiten auch äusserlich zum Ausdruck bringen und zugleich folgenden weiteren Zweck erreichen konnte.

Seit der ersten Veröffentlichung jener Arbeiten sind viele Physiker auf diesem Gebiete thätig gewesen. Die Versuche sind wiederholt, erweitert und vervollkommnet worden. Dabei haben sich die Haupt-

ergebnisse nur bestätigt gefunden; in einigen durchaus nicht unwesentlichen Fragen jedoch haben sich Irrtümer teils sicher herausgestellt, teils sind solche wahrscheinlich geworden. Der Verfasser ergreift also diese Gelegenheit, um die begangenen Fehler da anzuerkennen, wo er sicher ist, solche begangen zu haben und um die Wahrscheinlichkeit begangener Fehler da zu diskutieren, wo die sich zeigenden Schwierigkeiten auch jetzt nicht völlig gelöst sind. Zugleich ergreift er die Gelegenheit, um gewisse Fragen zu beantworten, welche immer und immer wieder persönlich an ihn gestellt wurden über den Zusammenhang der Versuche unter sich und mit der Maxwellschen Theorie, sowie über das eigentliche Wesen der letzteren Theorie überhaupt. Hierdurch dürfte das Verständnis der Versuche, besonders aber der theoretischen Arbeiten, nicht unwesentlich erleichtert werden.

Durch jede Buchhandlung zu beziehen. Bei Einsendung des Betrages direkt von der

Verlagsbuchhandlung

Johann Ambrosius Barth

in Leipzig.

LEIPZIG, OTTO DÜRR.

Dana's New "System of Mineralogy."

Sixth Edition, 1892; 1197 pp.; 1425 cuts; Price, $12.50.

Important Announcement.—This great work is promised by the publishers about May 15th. It is not a mere revision, but the entire work has been rewritten. It contains half more matter than the 5th edition, makes fundamental changes in the classification, etc. *Send for our full circular giving extended extracts from the preface, etc.* We offer the work for **only $10.00 net,** postage (40c.) or express charges extra. The number of orders so far entrusted to us has far exceeded our most sanguine expectations, and still they are coming in. May we not receive *yours?*

MAMMOTH VESUVIANITE CRYSTALS.

Eight enormous crystals of Vesuvianite have just been received from our Arkansas collector. They range in size from 1¾ inches in diameter up to 5 inches, and in weight from ¼ lb. up to 2¾ lbs. We believe these are the largest crystals of this interesting tetragonal mineral ever found at any locality. As we have so very few of them, send your orders soon.

Twin Rutiles, the best we have ever seen from Arkansas; a small lot of both groups and loose crystals.

CHONDRODITE, TILLY FOSTER MINE.

Mr. Niven recently visited again this wonderful mine and secured a number of the finest groups of brilliant Chondrodites we have ever had.

LAURIUM SMITHSONITES.

An unrivalled display of this rare and beautiful mineral is now to be seen in our store. Rich blues, greens, yellows, oranges, whites, drabs, etc., at 25c. to $2 50 for cabinet sizes and $3.50 to $20.00 for museum specimens.

OTHER RECENT ADDITIONS.

Rowlandite, the wonderful new Texas mineral, containing (according to Mr. W. E. Hidden) no less than 12 new elements and whose spectrum embraces 10,000 lines!!! A few type specimens, being all the available supply, at $5.00 to $20.00 each.

Thorite and **Orangite,** a fine lot, 50c. to $5.00.

Sicilian Sulphur, Hauerite, Melanophlogite, etc.; **Arizona** Vanadinite; **Elba** Hematite, Twin Pyrites, etc.

For many other new arrivals, see our recent "Bulletin," which will be sent free on application.

100 pages Illustrated Catalogue, 15c.; cloth bound, 25c.; Supplement "A", 2c. Circulars, free.

GEO. L. ENGLISH & CO., Mineralogists,

783 & 785 BROADWAY, NEW YORK.

CONTENTS.

Page

ART. XLIV.—Radiation of Atmospheric Air; by C. C. HUTCHINS 357

XLV.—Atmospheric radiation of Heat and its Importance in Meteorology; by C. ABBE 364

XLVI.—Experiments upon the Constitution of certain Micas and Chlorites; by F. W. CLARKE and E. A. SCHNEIDER 378

XLVII.—Qualitative Separation and Detection of Strontium and Calcium by the Action of Amyl Alcohol on the Nitrates; by P. E. BROWNING 386

XLVIII.—The Age and Origin of the Lafayette Formation; by E. W. HILGARD 389

XLIX.—Influence of Swamp Waters in the Formation of the Phosphate Nodules of South Carolina; by C. L. REESE 402

L.—Plattnerite, and its Occurrence near Mullan, Idaho; by W. S. YEATES; with Crystallographic Notes, by E. F. AYRES 407

LI.—Upper Silurian Strata near Penobscot Bay, Maine; by W. W. DODGE and C. E. BEECHER. With Map 412

LII.—Zinc-bearing Spring Waters from Missouri; by W. F. HILLEBRAND 418

LIII.—A Meteorite from Pennsylvania; by W. G. OWENS. 423

LIV.—Two Meteoric Irons; by G. F. KUNZ and E. WEINSCHENK. With Plate XIII 424

LV.—The Molecular Masses of Dextrine and Gum Arabic as determined by their Osmotic Pressures; by C. E. LINEBARGER 426

APPENDIX.—LVI.—A New Order of Extinct Eocene Mammals (*Mesodactyla*); by O. C. MARSH 445

LVII.—Notice of New Reptiles from the Laramie Formation; by O. C. MARSH 449

SCIENTIFIC INTELLIGENCE.

Chemistry and Physics.—Physical Properties of Fluorine, MOISSAN, 429.—Expansion of Chlorine in Violet Light, RICHARDSON: Dissociation of liquid Nitrogen peroxide, OSTWALD, 430.—New method of preparing Carbonyl sulphide, NURICSÁN: Preparation and Properties of Cæsium, BEKETOFF: Color of Cobalt-Solutions, ETARD, 431.—Method of showing Electrical Waves, LECHER: Permanent Magnetic Field, W. HIBBERT: Dielectric Constant and Conductivity, M. E. BOUTY: Aberration, RAYLEIGH, 432.—Kirchhoff's Law and the radiation of Gases, E. PRINGSHEIM, 433.

Geology and Natural History.—Note on distribution of upturned Cretaceous beds of Brit. America, G. M. DAWSON, 433.—Preliminary Report on the Coal-deposits of Missouri, A. WINSLOW: Baltimore, with an account of the Geology of its environs, WILLIAMS, 435.—Annuaire Géologique, L. CAREZ et H. DOUVILLÉ: Supplementary Appendix to Travels amongst the Great Andes of the Equator, E. WHYMPER: Concerning principles which accompany chlorophyll in leaves, ETARD: Structure of the ovule and the development of the embryo-sac in Vincetoxicum, CHAUVEAUD, 436.—Researches regarding the effect of leaf-removal in the case of grape-vines, A. MUNTZ: The Italian Botanical Society, 437.

Miscellaneous Scientific Intelligence.—Latitude Observations at Waikiki, on the island of Oahu, Hawaiian Islands, 438.—National Academy of Sciences, 441.

Obituary.—SERENO WATSON, 441.